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MAILPHONE: A NEW CONCEPT IN ELECTRONIC MAIL NETWORKING

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1. INTRODUCTION

1.1 Summary

This technical report covering a six-month period (July-Dec '80) is sub-
mitted in response to the requirements of Contract No. N00014-80-C-0755,
the MAILPHONE project. The MAILPHONE is a demonstration project in "man-
machine-relations (MMR)." The intent of this project is to show that new
approaches to man-computer interface design can overcome certain serious
problems associated with the under-utilization of military computer
systems. In the present project, the approach was to select a useful
military computer system which was poorly designed from MMR viewpoint, re-
design it with careful emphasis in the key MMR areas, and document the
improvements in acceptance and performance.

The military computer system selected for improvement was the ARPANET
electronic mail system. The MMR improvements were realized by a complete
redesign of the electronic mail interface, and demonstrated by the MAIL-
PHONE, a microprocessor-based system featuring a desk top unit purposely
designed to resemble the familiar telephone. The MAILPHONE, while complex
technologically, is designed to be operationally both simple and friendly.
Three desk units have been fabricated, and two complete prototype systems
are in development. When completed, they will be evaluated empirically
in terms of acceptability, personality, and performance.

Subsequent sections of this report provide a detailed description of the
MAILPHONE system design. Section 2 covers the system functions and the
user interface. The prototype hardware design is presented in Section 3.
The prototype software design is described at the functional level in
Section 4.

1.2   MMR Problem Analysis

Despite the proliferation of computers in civilian and military organi-
zations, acceptance and exploitation of the machines by their intended
users is still far from optimum. Numerous examples exist of computer
systems which are designed to high expectations, but which are in
essence rejected by their user populations, and which consequently
remain under-utilized and ineffective through their costly life.

The problem areas which underlie acceptance and rejection appear to go
beyond the usual "human factors" concerns of legibility, control/display
design, accessibility, and the like, and even beyond the actual utility
of the system. Rather, they resemble in some ways the social issues
surrounding race relations among people. That is, the users act as if
the computers were an "alien race" introduced into their midst. They
form likes and dislikes on the basis of factors which affect them in a
highly personal manner. These factors rest partly on past prejudice
early in the contact. Once established, they are later modified with
great difficulty, if at all. One may hypothesize several underlying
reasons for poor relations between man and machine. The root may be
cultural. That is, many people may harbor a basic mistrust of computers.
In fact, a nationwide survey found that 54% of the respondents believe
that computers are dehumanizing, 47% feel that computers often make
mistakes, and 33% feel that computers will decrease our freedom.

Another cause may be the lack of specialization associated with computers.
Since the general purpose computer cannot be identified with any single
functions, some people may misunderstand its use and application potential.
In other words, when a computer or terminal is presented to them, these
people may resent that it was not specially designed and customized with
a specific function intention in mind (namely, their own).

Finally, the nature of a user's background may impact upon his attitudes toward computers. For example, Freedy, Weltman, and Lyman (1972) found such an effect among subjects who interacted with a computer model which was learning the appropriate strategy to employ in a path-following task. Those with a technical background tended to eagerly await the point at which the computer had adapted sufficiently to begin making recommendations, while those with a nontechnical background tended to regard the computer as an interference.

In any case, it is possible to identify some specific areas of concern in man-computer-relations; these include:

(1) Lack of confidence, reflecting perceived unreliability, often resulting from failures, errors, or breakdowns in the sensitive early stages of system introduction.

(2) Divergence from perceived function, where the hardware or software manifestation of the system is at odds with the user's idea of what it does or should do.

(3) Divergence from individual needs, where the user feels that his specific requirements, preferences, tastes, etc., are ignored or even offended by specific system characteristics.

(4) Divergence from individuality, where the user feels that he is unable to influence the system personally.

(5) Threat to privacy, where the user feels he or she is liable to some form of exposure (data or decisions) as a result of system utilization.

(6) Threat to security or self-esteem. Of particular
importance to acceptance, this often reflects the
reluctance of well-placed users to make themselves
look foolish by failing to master a seemingly complex
new technology. It may also reflect a personal
conclusion that one's job is vulnerable to computer
encroachment; or, alternatively, that computer utili-
zation diminshes the status of that job by incorporating
menial elements.

Table 1-1, which summarizes the results of a study relating reasons for
resistance to management computer systems to job level, is an interesting
addition to these points. As seen, resistance rests on a broad range of
reasons. But at the top management level, which is not only the final
decision making level, but which also sets the tone for an organization,
resistance is based largely on feelings of unfamiliarity, insecurity, and
ambiguity. This type of feelings are most likely associated with computer
systems as a class, rather than with a specific system under consideration.
Accordingly, MMR problems of this nature are frequently not as obvious to
system designers as are those centering around system performance, such
as processing capabilities, data handling capacity, response speed, etc.

However, since a system which is rejected apriori cannot begin to fulfill
its performance objectives, it is evident that improved MMR's should have
a highly significant effect on improving total system effectiveness. What
is required is an established set of MMR design principles, easily under-
stood and applied, which will guide computer system designers in specific
design situations. The proposed project is a significant step toward the
application of MMR design to military computer systems.

TABLE 1-1

REASONS FOR RESISTANCE TO MIS BY WORK GROUPS. (Adapted from
G.W. Dickson and John K. Simmons, "The Behavioral
Side of MIS," Business Horizons, August 1970, p. 68.)

	Operating (nonclerical)	Operating (clerical)	Operating Management	Top Management
Threats to economic security		X	X	
Threats to status or power		X	X	
Increased job complexity	X		X	X
Uncertainty or unfamiliarity	X	X	X	X
Changed interpersonal relations or work patterns		X	X	
Changed superior-subordinate relationships		X	X	
Increased rigidity or time pressure	X	X	X	
Role ambiguity		X	X	X
Feelings of insecurity		X	X	X

<u>Major MMR Factors</u>. Preliminary analysis of MRR in computer systems identified six major areas of concern; these are:

   (1) <u>Configuration or Form</u>: The physical aspects of the system, particularly as they relate to its integration into the user's work environment.

   (2) <u>Personalization</u>: All system features which make it responsive to individual needs and preferences, and which promote a feeling of individual attachment to it.

   (3) <u>Interface Functions</u>: Those features which affect actual user contact with the system -- predominantly concerned with the modes and forms of information exchange between system and user.

   (4) <u>Subsidiary Incentives</u>: Extra features provided by the system, beyond its primary function, which increase its attractiveness and promote familiarization and practice.

   (5) <u>Indoctrination</u>: The philosophy, methodology, content, and circumstances of the user's introduction to the system, including descriptions of its purpose, its function, its underlying technology, its unique characteristics, and its potential job implications.

   (6) <u>Instruction</u>: The means by which the user learns to operate the system. Of particular interest is embedded instruction, in which the system itself provides the instructional media.

Other factors, such as social and organizational context of use, may also affect MMR. But both in this study, which is directed toward an existing system, and also in general system development, such factors tend to be out of the designer's control, and so are of lesser practical importance.

1.3 Computer System Selection

The system selected for improvement was the ARPANET electronic mail system. The ARPANET is a network of interconnected computers and terminals which currently serves 2,200 DOD or DOD-connected individuals, many of whom act as contact points for entire organizations. In addition to tremendous computing resources, ARPANET users have available one of several electronic mail services. These services provide the capability for composing messages at a terminal and for routing them to the incoming mail files of other ARPANET users. Since the ARPANET was not originally designed for communication, or for non-technical users, its MMR is uniquely bad. The result is suboptimum use of this resource. In sum, the ARPANET was selected because:

(1) It is an existing system, i.e., it is already installed, operating, and has a performance history.
(2) Its usage is job related, i.e., contributes in a real way to the user's job.
(3) Its usage is voluntary, i.e., functions can be accomplished manually by the user if desired; this presumes a middle management or upper management user.
(4) It is unclassified.
(5) It is suboptimally designed from an MMR viewpoint, i.e., attitudinal problems currently exist; these seem to affect performance with system.
(6) It is accessible in the sense that it is possible to perform experimental manipulations, i.e., to modify user interface and to obtain performance measurements.

In addition, selecting a system dedicated to communication and information distribution was considered desirable for three main reasons. First, communication systems generally involve continuous close contact between man and machine, thus they are likely to aggravate adverse MMR. Second, such systems are of growing importance to the military at all levels of organization, from squads to the Office of the Chief of Staff. Finally, communications systems have been previously examined in psychological contexts closely related to MMR, so that there is a body of empirical data to aid in the planning of our proposed study and the interpretation of its results.

1.4   System Concept

The MAILPHONE system proposed for electronic mail handling is designed to address directly those problems existing in current electronic mail systems such as the ARPANET and also to incorporate positive MMR factors as outlined in Section 1.2. The Perceptronics MAILPHONE is a complete redesign of the electronic mail interface. Physically, this microprocessor-based, stand-alone system consists of two units; the Desktop Unit and the Control Unit. The MAILPHONE Desk Unit (shown in Figure 1-1) is purposely designed to resemble an extension of the familiar telephone rather than a version of the more controversial computer terminal. The MAILPHONE has all of the capabilities and characteristics of an executive telephone, in addition to its electronic mail and auxiliary functions. Inset into the MAILPHONE Desk Unit is a 40-character LED display, on which the user can view or compose messages. Message composition is done via a flat keyboard, approximately the shape and dimensions of a small pad of paper. When not in use the keyboard slides neatly under the Desk Unit.

A key feature of the interface is the LED displays associated with the eight special-function buttons. These displays are under software control, so that the legends change adaptively depending on which top-level function is evoked. This provides for great flexibility of operation without confusion to the user.

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FACE PLATE

12 FEBRUARY 1980   11:32 AM

MAIN
HOUSING

MAIL OUT
QUIKDIAL
EXTRAS
HELP
MAIL IN
STATUS
DIRECTRY
CANCEL

● AUTODIAL CHECK STATUS ●

EXTENDED
KEYBOARD
HOUSING

SLIDING
KEYBOARD
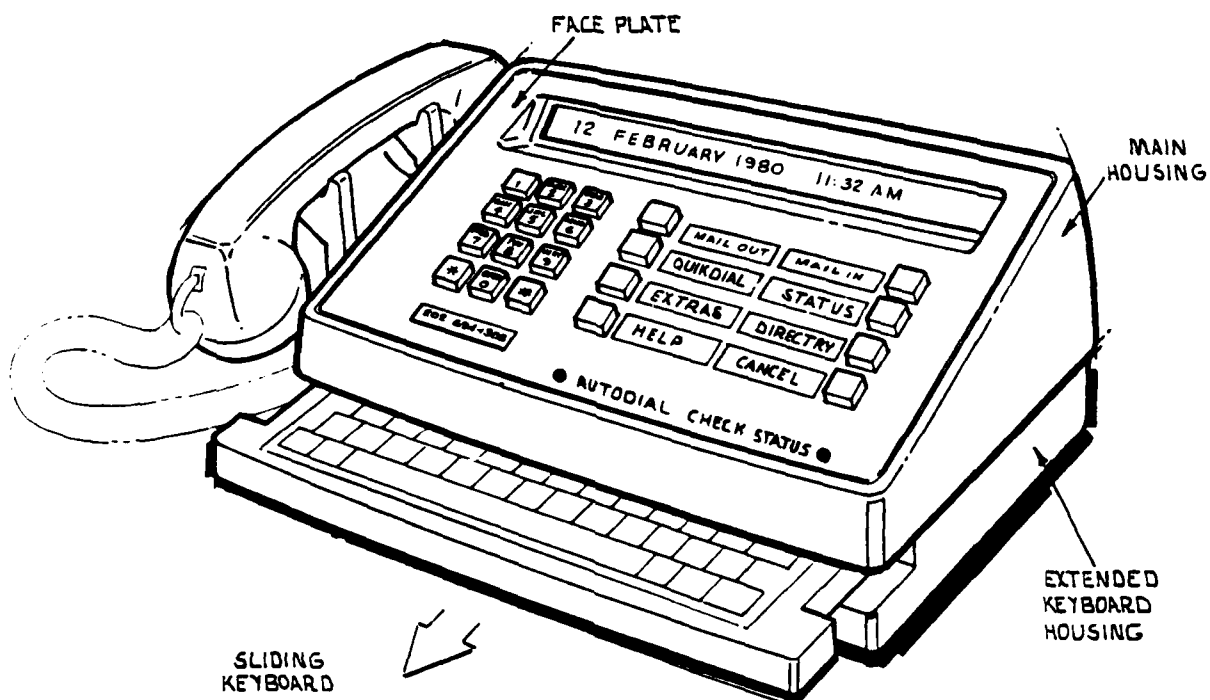
FIGURE 1-1.
MAILPHONE DESK UNIT

A single cable connects the MAILPHONE Desk Unit to its Control Unit, which is located in some convenient nearby place. This cable houses both the standard audio and RS-232 connections. The Control Unit is a microcomputer with a limited amount of local storage. When the MAILPHONE is used as a telephone, the Control Unit is a channel for regular telephone service. However, when used to access electronic mail services or other MAILPHONE features, the Control Unit also provides the following functions:

(1) Automatic connection to other MAILPHONES.
(2) Local interface personalization by the user.
(3) Auxiliary services such as alerting, autodial, text and audio message editing, etc.
(4) Reference information on MAILPHONE use.
(5) Printer control and message formatting.

Mail service and other auxiliary services are all located within the microprocessor control unit. The MAILPHONE, like the telephone, is always available to the user, in contrast to remote ARPANET computers or network interfaces which may often be unavailable due to hardware or communication problems. Hardcopy of electronic mail messages are provided by a small printer also controlled by the microcomputer.

1.5   MMR Improvements

The overall goal of this project was to produce a system which is highly desirable to the user -- in essence, instantly attractive. The approach was to make it simultaneously modern, friendly and transparently convenient and helpful. Individual improvement categories include:

(1) Form. Specialized industrial design provides details of shape and finish which accentuates the "advanced telephone" nature of the unit, while incorporating such features as quality, substantiality, utility and unobtrusiveness.

(2) Personalization. Users have several options for physical and functional personalization of the MAILPHONE: these options focus on promoting attitudes of ownership and security. Future emphasis will be on adjusting the "personality" of the interactive software for compatibility with the user's preferences.

(3) Interface Functions. Obnoxious traits of the present ARPANET interface have been eliminated, and new interactive functions have been provided to give the interface a simpler and friendlier character. This includes relieving the user of "overhead" operations in sending and receiving messages, providing clear indications of what has occurred, and what to do in the case of errors, and presenting the message information in well-formatted and quickly assimilable forms.

(4) Subsidiary Incentives. The prototype system features computer games such as blackjack (Twenty-1) and patterns which are expected to entice the user to the system, and promote "painless" indoctrination.

(5) Instruction. The MAILPHONE offers embedded instruction in the form of system prompts in response to HELP function key usage.

1.6   System Production and Evaluation

The design and prototype production of the MAILPHONE Desk Units was subcontracted to S.G. Hauser and Associates, Inc. of Woodland Hills, California. This company has had previous experience with telephone system designs. The design program proposed by S.G. Hauser included a very accurate layout developed by SGH and based on the hardware specified by Perceptronics.

Rough sketches were done based on this layout and a dimensional model was fabricated by SGH. This "soft" mockup (i.e., non-working model) was used to determine Desk Unit configuration and volume, and representative final appearance.

After approval of the model and general approach, SGH generated a final drawing and package layout of the housing parts. They also supervised the fabrication of the short-run molds; in this case they were fiberglass since only two units were made. SGH were responsible for providing Perceptronics with three completed prototype Desk Units. They supervised the fabrication of the housing as well as the mounting of the Desk Unit electronics. The demonstration MAILPHONE units resemble production systems as closely as possible in look, feel, and function, but are actually assembled from commercial and custom components using prototype and small-run techniques.

The MAILPHONE system will eventually be evaluated by a selected sample of ARPANET users. The user group will be selected on the basis of having a job-related communications need, and a potential for improved communication effectiveness.

2. MAILPHONE SYSTEM FUNCTIONS AND USER INTERFACE

2.1   Overview

Prior to going into the details of the MAILPHONE user interface and system
design, it is important to recognize that the MAILPHONE is being designed
for the casual user. J. Martin (1973) describes the casual user or
operator as one who uses the terminal only occasionally, spending most
of the day doing something different. Such users have little, if any,
training in terminal usage. For them,

> "the man-machine interface must be designed to appear
> as natural as possible or [their] bewilderment will
> quickly turn into annoyance, criticism, or behavior
> that amounts to rejection of the system."

The main characteristics of the casual user can be summarized under three
main categories:

(1)   Consequences of Infrequent Use. The casual user forgets
       much more than does the dedicated user, and hence is very
       prone to error if allowed free input. It is, therefore,
       better to offer him a "constrained choice" interface which
       exposes a relatively small number of items to consider at
       any one time, and implicitly or explicitly guide the user to
       a solution. It has been found that users tend to forget
       details taught during their initial training (if any) which
       are not regularly reinforced during normal system use. Such
       training should therefore be restricted to covering the main
       operational concepts, and on-line help should be readily
       available from the system itself. Casual users often would
       like to specify their needs vaguely, using the system's output

to understand their own requirements better and to build
confidence. Their typing ability, especially with non-
alphabetic characters, is usually poor.

(2) Need for a "Natural"-Feeling System. In general, a casual
     user resents being forced to construct syntactically formal
     and precise queries. He prefers to think of data in more
     real-world terms than those of system objects and names.
     An ideal system should not be legalistic about interpreting
     the intent of an actual query. A courteous, coherent and
     rational dialogue flow is important, using terms the user can
     understand, while maintaining a conversational context.

(3) Limited Mathematical and Programming Skills. Such users are
     unlikely to pose very complex queries, and therefore a
     "relationally complete" interface is not as vital as is often
     supposed. In particular, they tend to avoid logical operators
     for fear of misuse. Implicit logic is, therefore, preferable
     to explicit logic.

The foregoing discussion of the casual user provides the basis for the
design of the MAILPHONE user interface. The remainder of this section is
devoted to describing the required functional capabilities, the system
concept, the user interface and the associated interface functions for
electronic mail handling, normal phone call and subsidiary incentives.

2.2   Functional Capabilities

Since the MAILPHONE is a complete redesign of the electronic mail inter-
face, its primary function is to provide electronic mail handling
functions. To this end, the MAILPHONE can transmit or receive text or
prerecorded spoken messages to and from other MAILPHONES. Included in

the text message transmission process are message composition, modification deletion, display, and alert capabilities. Included in text message reception are automatic recognition, answer, storage, display and alerting capabilities. The MAILPHONE also serves as an executive telephone. In addition to manual telephone dialing, the MAILPHONE provides speed-dialing and auto-redial capabilities. To entice a wary first-time user, the MAILPHONE offers an auxiliary functions package that includes fun and game routines such as blackjack, and pattern matching. The prototype system offers some personalization features such as user-selectable text generation and display modes and hardcopy options.

2.3   User Interface

The MAILPHONE user interface is the Desk Unit. It consists of the normal telephone interface (keypad and handset), a set of 'soft' (variable legend) function keys, a pullout keyboard, a single line display and two LED indicators. The variable legend function keys are used to invoke executive phone and electronic mail handling functions. The pullout keyboard is used for text message composition and on-line directory update. The single-line readout is used for text display during message composition, transmission, viewing and reception. One of the two LED indicators is used for signaling when autodial is in progress. The other "lights up" when the system detects faulty conditions (e.g., cassette tape not positioned properly) that prevent the system from functioning correctly.

2.3.1 Prototype Desk Unit Fabrication. The Desk Unit is constructed around the standard Multi-button Desk Telephone housing assembly (model 2830-60-11). The front panel or face plate is designed to accommodate the MAILPHONE user interfaces along with the standard touchtone keypad purchased from Grayhill, Inc. The base of the unit, which extends downward, houses the retractable keyboard. Refer to Figure 1-1 for a pictorial view of

The Desk Unit. The Desk Unit also houses the various electronic components that make this unit an intelligent interface device. The industrial design and assembly of these parts was performed by S.G. Hauser and Associates. The following subsections give fabrication details in each of the above mentioned areas.

Face Plate. The face plate is designed and fabricated from Acrylontrile-Butadiene-styrene (ABS) copolymer molding compound identical to the main Desk Unit housing assembly. The dark brown face plate is color-coordinated to match the beige main housing. The face plate is fabricated from a single piece of ABS material with cutouts for the 12 touchtone keypad switches, the eight function switches (both purchased through Grayhill, Inc.) and the AUTODIAL and CHECK STATUS L.E.D.'s. Additionally, the cutouts for the 8 legend displays and the 40 character displays are provided with contrast filters (Panel-Graphic Gray 10) for improved viewing of the amber displays as well as providing a "dead front" effect when the displays are unlit.

Keyboard. The keyboard base plate is made from ABS with the outer rim painted to match the face plate. The keyboard assembly consists of the keyboard, the graphics overlay, the keyboard base plate and a sliding mechanism that allows the keyboard to smoothly slide in and out of the base housing. When not in use, the keyboard remains out of sight within the base housing of the Desk Unit. The sliding mechanism, fabricated from cold rolled steel, plated in clear cadmium (rust proof), houses two black Delrin movement guides. When out, the keyboard can be set at a slight tilt to facilitate simultaneous typing and viewing. The keys, mounted on a small ABS plate, are based on membrane-switch keyboard technology.

Electronics. Three printed circuit boards (PCB) contain all Desk Unit
electronic components. These PCB's are custom-designed to fit within
the Desk Unit housing as shown in Figure 2-1. These cards are electroni-
cally interconnected through the use of flexible, flat ribbon cables
with standard connectors.

The first board attaches directly to the face plate. The standard
touchtone keypad, the 8 function switches and associated legends and
the two L.E.D.'s are mounted on this PCB along with the associated drive
and interface electronics components.

The second PCB contains the 40 character displays, the 8085 microprocessor
and memory IC's and associated interface electronic packages. The speaker
and Control Unit interface electronic IC's are mounted on the third PCB.
This circuit card is mounted directly to the rear of the main housing.
The Control Unit interconnect cable, attached to this card, connects to
the serial interface from the main computer via a hole cut in the back
of the Desk Unit enclosure (see Figure 2-1).

2.3.2 Variable Legend Function Keys. There are eight function keys
each with an associated 8-character L.E.D. readout that provides the
variable legend capability. The eight readouts under software control
display the appropriate self-explanatory legend for each of the eight keys
based on which top-level function was selected by the user. The main
advantage of the variable legend function keys is that they provide great
flexibility of operation without confusion to the user. HELP and CANCEL
legends are always associated with the two bottom-most keys. The purpose
of the HELP key is to indicate to the user the possible system states
associated with a given top-level function that are accessible via
suitable keypresses from the current state. The purpose of the CANCEL

40 CHARACTER LED DISPLAY

MOLDED FACE PLATE HAS DISPLAY
FILTER EMBEDDED IN IT

STANDARD TELEPHONE
TOUCHTONE DIAL - 8 SWITCHES
AND LED DISPLAYS

8085 μ PROC.
RAM/PROM

SPEAKER
& ADDITONAL
ELECTRONIC
INTERFACE

IC CHIPS

INTERCONNECT
CABLING

RETRACTABLE
KEYBOARD

METAL PLATE

CABLE
CONNECTED TO SERIAL
INTERFACE FROM MAIN
COMPUTER AND POWER
SUPPLY

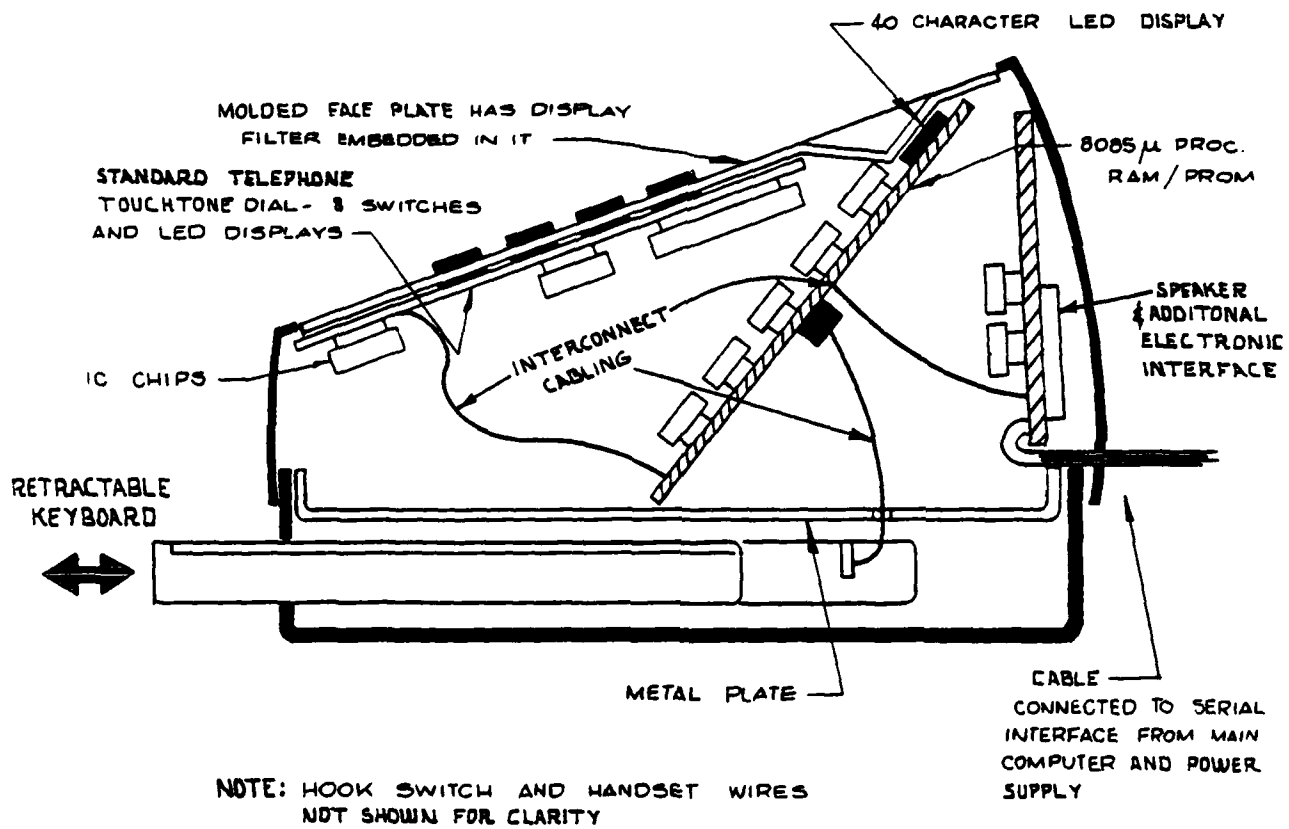NOTE: HOOK SWITCH AND HANDSET WIRES
NOT SHOWN FOR CLARITY

FIGURE 2-1.
DESK UNIT PHYSICAL LAYOUT

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key is to abort the ongoing activity regardless of the prevailing function menu hierarchy and return to top-level function menu associated with the QUIESCENT system state.

2.3.3 Single-Line Display. A single-line 40-character alphanumeric yellow L.E.D. display (Hewlett-Packard HDSP-2001) is used to read and compose electronic mail. The 8-inch display is inset into the MAILPHONE at an angle suited to comfortable viewing. The yellow L.E.D.'s were selected on the basis of being least fatiguing to the eye. The HDSP-2001 display is a .15-inch 5X7 yellow L.E.D. array that is available in 4-character clusters. The HDSP-2001 has an integral untinted glass lens. The MAILPHONE employs the PANELGRAPHIC Gray 10 front panel contrast filter recommended for use with the HDSP-2001.

2.3.4 Display Modes: Study and Selection. Two distinct display modes are feasible for presenting textual information on the MAILPHONE 40-character single-line display. The first is "Saccadic Scrolling" in which the display is scrolled vertically, i.e., as if one were reading a newspaper column one line at a time. In Saccadic Scrolling, an entire line remains on the display for a certain period of time, and is then replaced instantaneously by a different one in the same location. The resulting effect is that of new material appearing instantly in the visual field, much as it does during the fixation pauses between saccadic in normal reading. It is this feature that motivates the choice of the term "Saccadic Scrolling." Saccadic Scrolling can be performed automatically or manually. In the automatic mode, the text is advanced automatically at a pre-established uniform rate but can be adjusted during the course of reading by the user. In the manual mode, the text can be made to advance to the next line or return to the previous line via two control function keys: 'NEXT LINE'or 'PREVIOUS LINE.' In the manual mode, any change in the displayed material requires a specific key-press.

The second display mode is the conventional <u>Times Square</u> mode. In this mode, the text appears to flow from right to left, moving one character at a time, until the end of the passage. This is accomplished by rewriting the text with each character moved one position to the left, causing the left most character to disappear and a new character to appear from the right. The display rate in this mode can be made vaiable with the implementation of a 'FASTER' and 'SLOWER' key. Pressing one of these two keys causes an increment or decrement in the apparent speed (i.e., the frequency of rewriting the line with a character shift) of the text on the screen. An additional 'REVERSE' key causes the text to reverse direction and move from left to right, while pressing the 'ADVANCE' key causes the resumption of right to left motion.

The two display formats, i.e., the Saccadic Scrolling (vertical scrolling) and Times Square (horizontal scrolling) were evaluated in a reading performance (both speed and comprehension) experiment conducted at University of California, Santa Barbara (Sekey, 1980). The results of this experiment were that for reading speed, Saccadic Scrolling (both automatic and manual) was vastly superior to the Times Square mode (see Table 2-1). For comprehension, Saccadic Scrolling was once again superior to the Times Square mode. Manual Saccadic Scrolling mode was found to be superior to the automatic Saccadic Scrolling mode (see Table 2-2).

After analyzing the results of their experiments, the experimenters attributed the poor reading performance obtained by the Times Square mode to the conflicts that arise between letter movement and saccadic eye movement. Given the results of this study, Saccadic Scrolling was selected as the message viewing mode for the MAILPHONE.

TABLE 2-1

READING TIME (MINUTES) AND SPEED (WORDS/MINUTE) FOR SACCADIC SCROLLING VERSUS TIMES SQUARE

	VIEWING METHOD					
	SACCADIC SCROLLING				TIMES SQUARE	
	Manual		Automatic			
	Time	Speed	Time	Speed	Time	Speed
Mean	2.53	189	2.29	209	5.74	84
Median	2.36	203	2.25	213	5.46	88
Std. Dev	0.69		0.61		2.5	

TABLE 2-2

COMPREHENSION SCORES (% CORRECT) FOR SACCADIC SCROLLING VERSUS TIMES SQUARE

	VIEWING METHOD		
	SACCADIC SCROLLING		TIMES SQUARE
	Manual	Automatic	
Mean	60.5	58.9	53.5
Median	67.0	50.0	58.5
Std. Dev	32.2	25.3	24.0

The only other message viewing option issue arises during text gene-
ration. In text generation, the limiting modality in message viewing is
how fast the user can type, not how fast he can read, so reading speed is
not a criterion. The Times Square mode does give a sense of continuity
as words gradually disappear a character at a time, not a line at a time.
Also, in comprehension, the Times Square mode compared favorable with
Saccadic Scrolling. It is therefore felt that the Times Square viewing
mode be provided as an option in text generation in the MAILPHONE follow-
on effort. The prototype system, however, will have Saccadic Scrolling
as the message viewing mode in all instances.

2.3.5 Pull Out Keyboard. The MAILPHONE possesses a retractable key-
board that can be pulled out for message composition and can be tucked
away upon message completion. The keyboard once out can rest on the
desk in one of two user preferred positions: completely flat on the desk
or slightly tilted. The custom-made keyboard fabricated by Silver Graphics,
Inc. employs membrane technology. This technology is highly suited to
making flat dirt-proof keyboards. A computer-generated "beep" that
accompanies each keypress gives the keyboard a very positive feel. The
keyboard features a full ASC11 character set, 7 special function keys,
CTL (control), SHIFT, SHIFT LOCK, and RET(URN). The single-line text
edit keys include ↑ , ↓ ,→,←, DEL(ETE) and INS(ERT). The CTL key, a
key similar to SHIFT, offers full functionality for the computer-oriented
user by providing him both square and angle brackets often used in writing
mathematical expressions. Pressing the RET(URN) key during text gene-
ration advances the display by one line and left justifies the cursor. The
edit keys and their associated functions are discussed in detail in the
next subsection, MAILPHONE Text Editor.

2.3.6 <u>MAILPHONE Text Editor: Interface and Capabilities</u>. The MAIL-
PHONE system has a text generation and edit capability geared to a single
line 40-character display. The specific edit keys and their functions
are identified in the following paragraphs.

1. [→] This edit key is used to move the cursor to the right one
character at a time. When the cursor is positioned on the 40th character,
pressing this edit key results in the display of the next line with the
cursor left justified.

2. [←] This edit key is used to move the cursor to the left one
character at a time. When the cursor is positioned on the first character,
pressing this edit key results in the display of the previous line with
the cursor right justified.

3. [↑] This edit key is used to display the previous line with the
cursor in the exact same position. When the line being displayed is the
first line, the display remains unaltered when this key is pressed.

4. [↓] This edit key is used to display the next line of text with
the cursor in the exact same position. When the line displayed is the last
line of text, the display remains unchanged when this key is pressed.

5. [RET] This edit key is used to display the next line of text with
the cursor left-justified.

6. [DEL] The DEL(ETE) key is used to delete text one character at a
time. When this key is pressed, the character under the cursor is deleted
and all characters to the right of the cursor are shifted left by one
column as shown in the figure below for the case when only two lines are
present.

```
                              ┌─Column m
                              ↓
DISPLAYED LINE  │ A B C D                          V W │

NEXT LINE       │ X Y Z                                │


                    "DEL"
                      Column m

DISPLAYED LINE  │ A C D                          V W X │

NEXT LINE       │ Y Z                                  │
```
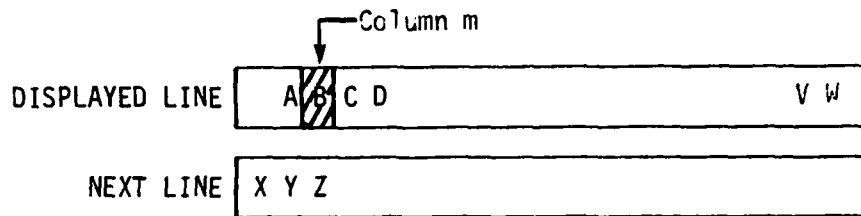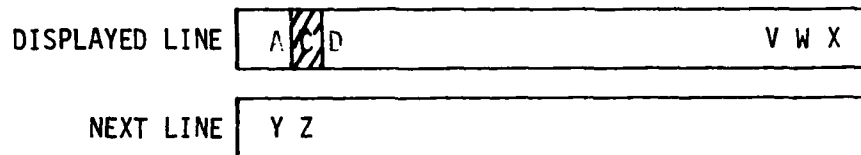
The DEL(ETE) key affects the displayed line and all subsequent lines.
This means that characters on subsequent lines are moved left one
column and that the character in column 1 of line n is moved to column
40 of line n-1 for all lines.

7. |INS| This key is used to insert character/text anywhere in the body
of the message. Pressing the INS key followed by the characters to be
inserted causes the inserted characters to appear in the display starting
at the initial cursor position. The following illustrative example
clarifies the use of the function.

```
                                   │ FLIGHT  33  IS  CANCELLED │
        "INS", < N >
                                   │ FLIGHT  33  IS  NCANCELLED │
            < O >
                                   │ FLIGHT  33  IS  NOCANCELLED │
            < T >
                                   │ FLIGHT  33  IS  NOTCANCELLED │
         " Space Bar "
                                   │ FLIGHT  33  IS  NOT CANCELLED │
```

2-12
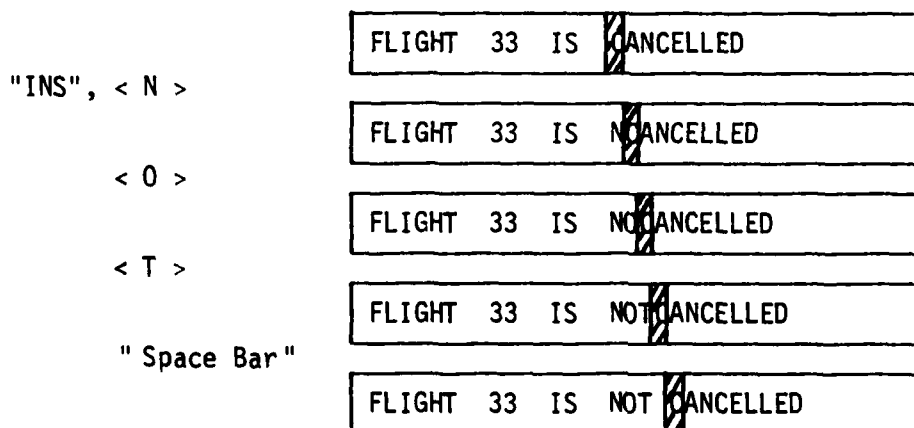
If insert results in greater than 40 characters (i.e., pushes a character over the right edge of the display), then:

(1) The character that was pushed off the edge is saved.

(2) The succeeding lines are searched until one is found that has a blank in column 40.

(3) If the line found in step 2 is entirely blank, then (another) blank line is added before the "found" line and this new line is designated as the "found" line.

(4) All characters in the "found" line are shifted to the right by one column.

(5) The line immediately preceding the "found" line is designated as line n.

(6) While line n is not the displayed line the following is done:

   (a) The last character of line n is moved to column 1 of line n + 1.

   (b) All characters of line n are shifted to the right by one column.

   (c) Designate line n - 1 as line n.

   (d) Back to step 5.

(7) The character saved in step 1 is put into column 1 of line n + 1.

2.4   MAILPHONE Interface Functions

The MAILPHONE functions are summarized in the function state overview diagram, Figure 2-2. The QUIESCENT state of the MAILPHONE is the top level or idle state, i.e., the state in which the MAILPHONE displays just the date and time and responds to outside calls and/or redials last busy number. From the QUIESCENT state, the user can press MAILOUT, MAILIN, QUIKDIAL, STATUS, DIRECTRY, and EXTRAS. Under MAILOUT, the user can create and distribute text and audio messages. Under MAILIN, the user can selectively view text messages or listen to audio messages. Under STATUS, the user can read the specific system problem or warning associated

with a lit CHECK STATUS L.E.D. indicator. The DIRECTRY function allows
the user to both modify (or update) and search the directory for the
intended recipient's number, and call him. The EXTRAS function offers
assorted subsidiary incentives such as fun and games routines and user-
modifiable MAILPHONE personality. The QUIKDIAL key can be used to perform
one of two functions. When preceded by a 2-digit directory code, it
allows the user to speed-dial a recipient's number without having to
enter the whole number. When pressed after receiving a "busy" signal
on a normal telephone call, it redials the previous unsuccessfully
attempted number. The CANCEL key allows the cancelation of any ongoing
activity. In the QUIESCENT state it can be used to turn QUICKDIAL off.
The HELP key allows the user to acquire additional information on the
variable legends associated with the displayed 'soft' function menu. HELP
also allows the user to get oriented in the MAILPHONE state space, i.e.,
informs the user what functions are accessible to him at any point in the
interaction.

It is noted here that one of the MAILPHONE functions originally proposed
was that it serve as an automatic answering machine. This feature has
been subsequently dropped after a careful re-examination of the MAILPHONE's
operational environment. The following paragraph provides the rationale
for this decision.

Functionally, the MAILPHONE is an advanced office automation tool for use
by an executive. In general, an office is equipped with a multiple phone
line system which is interconnected to the executive's phone by a receptionist
or secretary. This being the case, the automatic answering capability has
little significance in this multiline environment since the executive, when
he chooses not to answer calls, can inform the secretary/receptionist to
"screen/answer all calls" until further notice. For offices that do not
possess multiline systems, the automatic answering capability can be added
by purchasing and "hooking up" any one of the off-the-shelf available
automatic answering devices to the live call line as per the devices
instructions. With this implementation, incoming live calls will be auto-
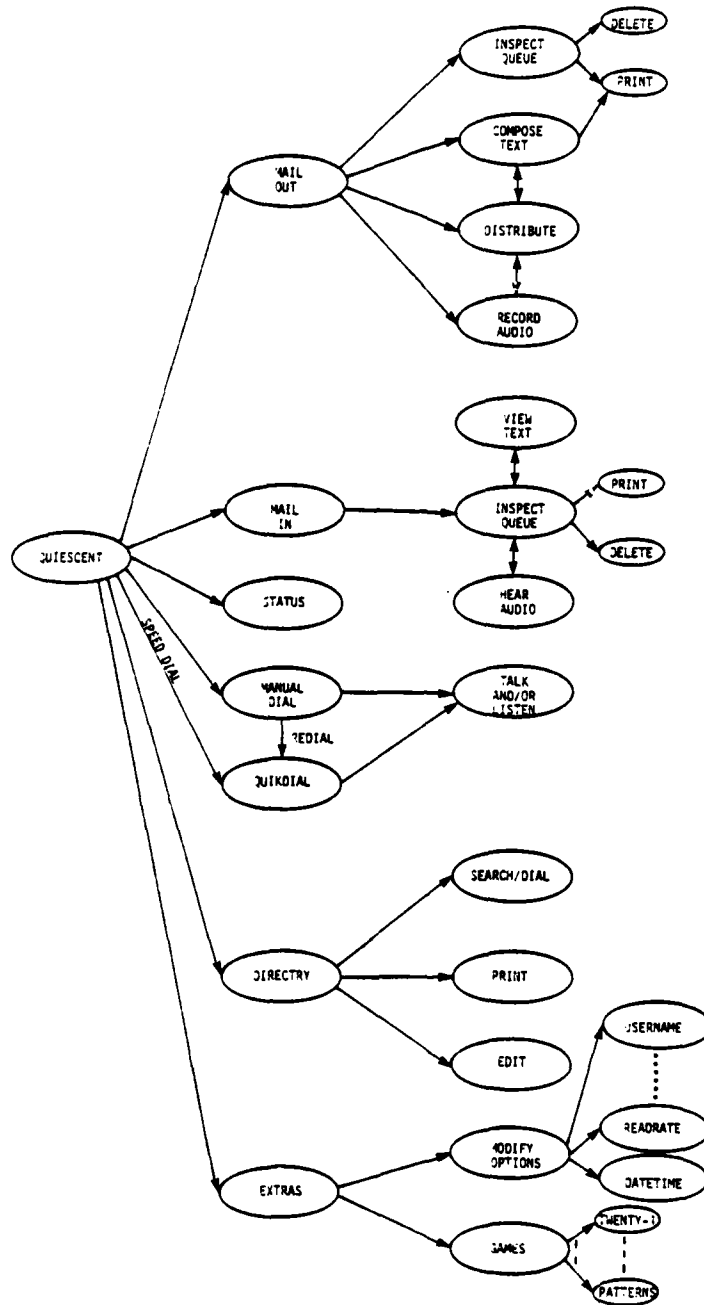matically answered on this line.

FIGURE 2-2.
MAILPHONE FUNCTION STATE OVERVIEW DIAGRAM

2.4.1 MAILOUT Function. The MAILOUT function of the MAILPHONE allows
composition of textual and audio messages and review of the outgoing
message queue. The MAILOUT function state transition diagram is given
in Figure 2-3. The associated variable legend hierarchy is given in
Figure 2-4.

The composition of a message involves either typing a message on a key-
board or recording a message through the handset. Each message has a
fixed header that can be created before or after composing the message.

The outgoing message queue can be reviewed under MAILOUT. The user can,
if he wishes, cancel (i.e., delete) specific messages from the pending
message queue. He can also get confirmation if a message was sent.
Deletion of outgoing messages can be performed automatically or by user
disposition. In instances where a message has not been disposed of by the
user, the system will prompt the user for disposition if the available
storage space falls below an a priori established threshold. If the user
disregards the prompt, the system will start deleting the oldest messages
to make room for new incoming messages or provide a busy indication to all
incoming messages depending on the option specified by the user under
the MODIFY subfunction found in the EXTRAS menu. A sample interaction
of the MAILOUT function is given in Appendix A.

2.4.2 MAILIN Function. The MAILIN function of the MAILPHONE allows
the user to select a message that he wishes to see (or hear) from his
incoming message queue (see Figure 2-5). The legends that are then dis-
played on the variable legend function keys depend on whether the message
is a text or an audio message. Upon message completion, the user can
review the same message by pressing REPEAT or select a new message. If
he wishes to select a new message from the queue after either reading a
text message or listening to an audio message, he simply presses MAILIN.
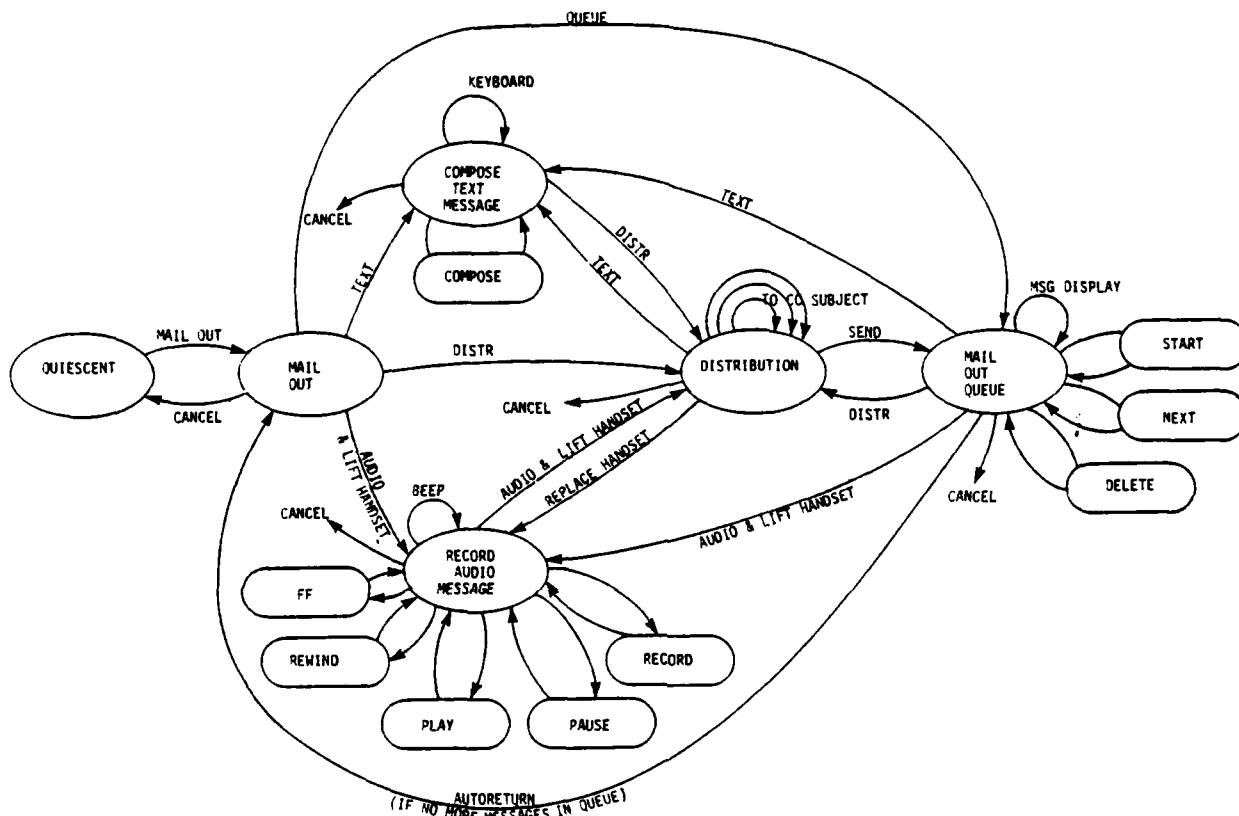This keypress causes the first entry in the queue to be displayed once

FIGURE 2-3.
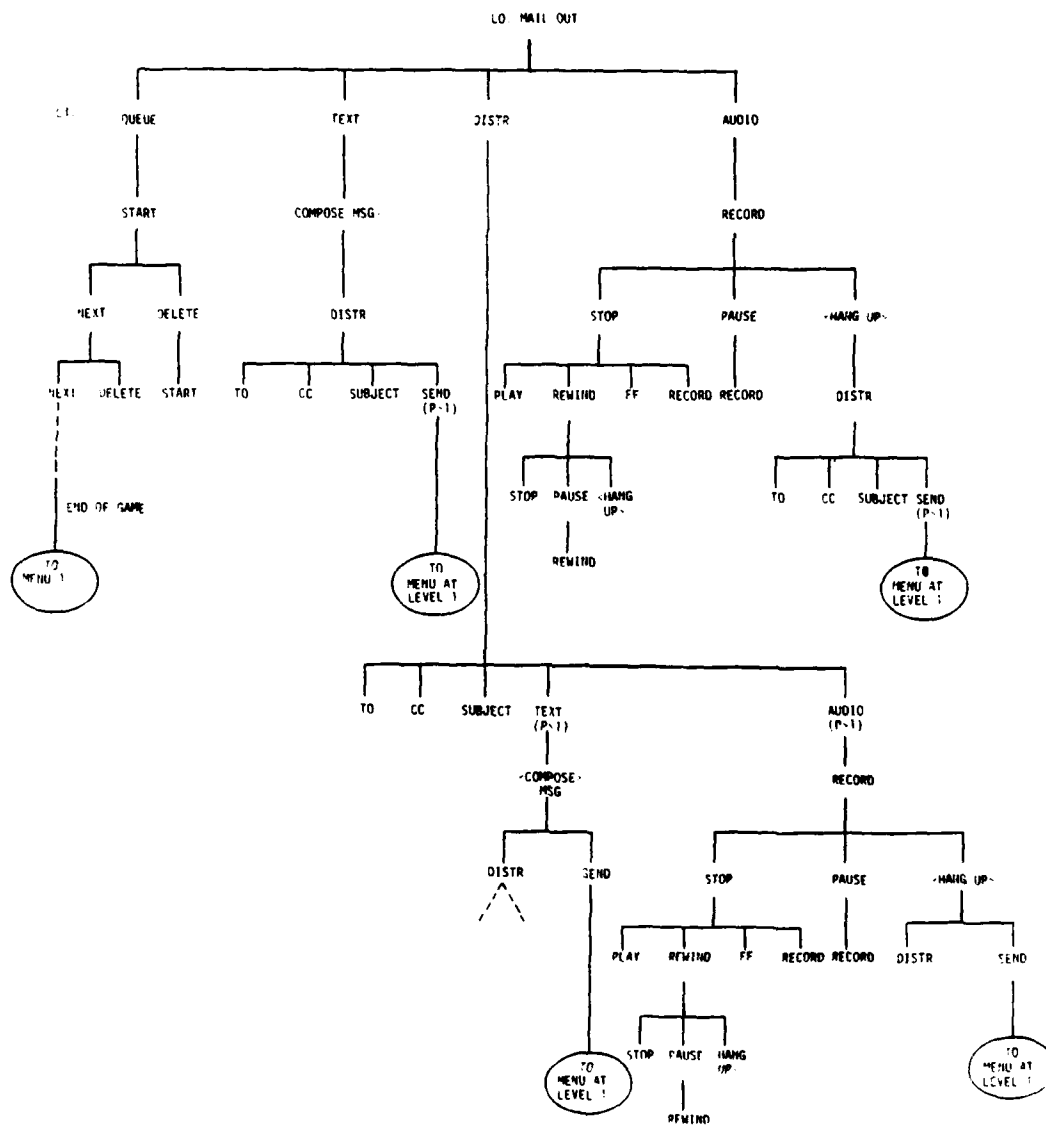MAIL-OUT STATE TRANSITION DIAGRAM

FIGURE 2-4.
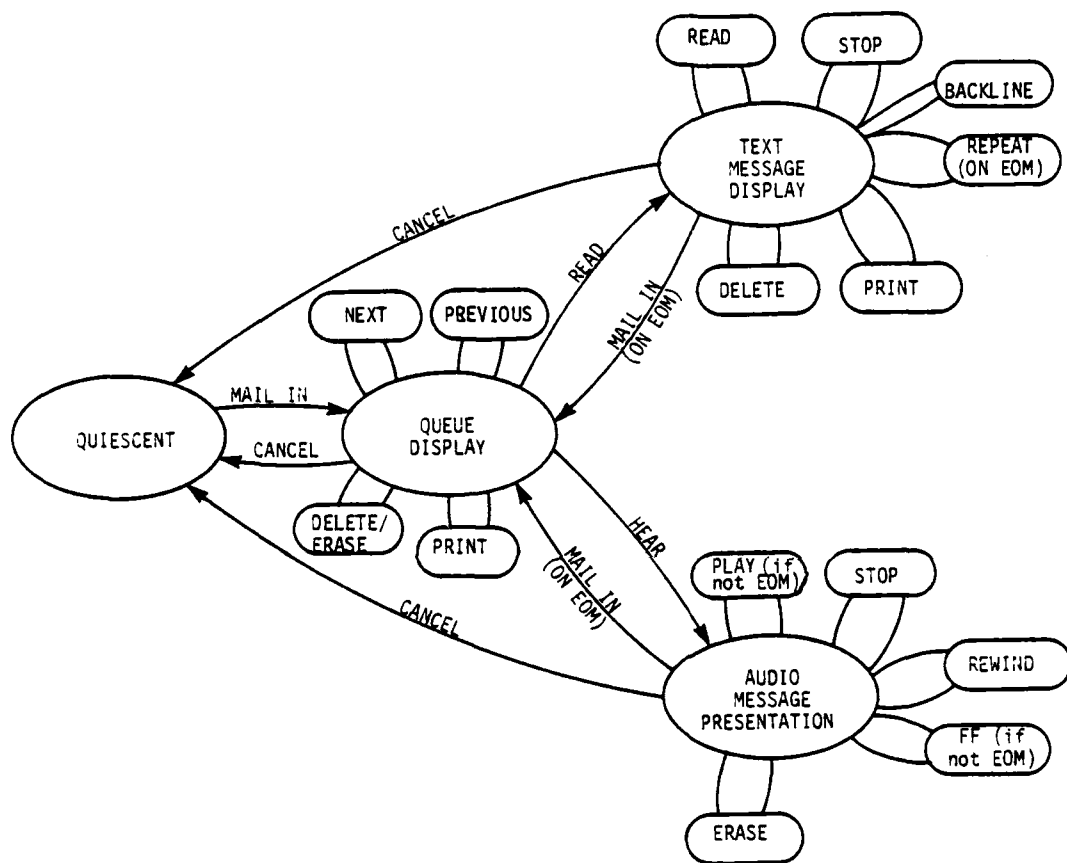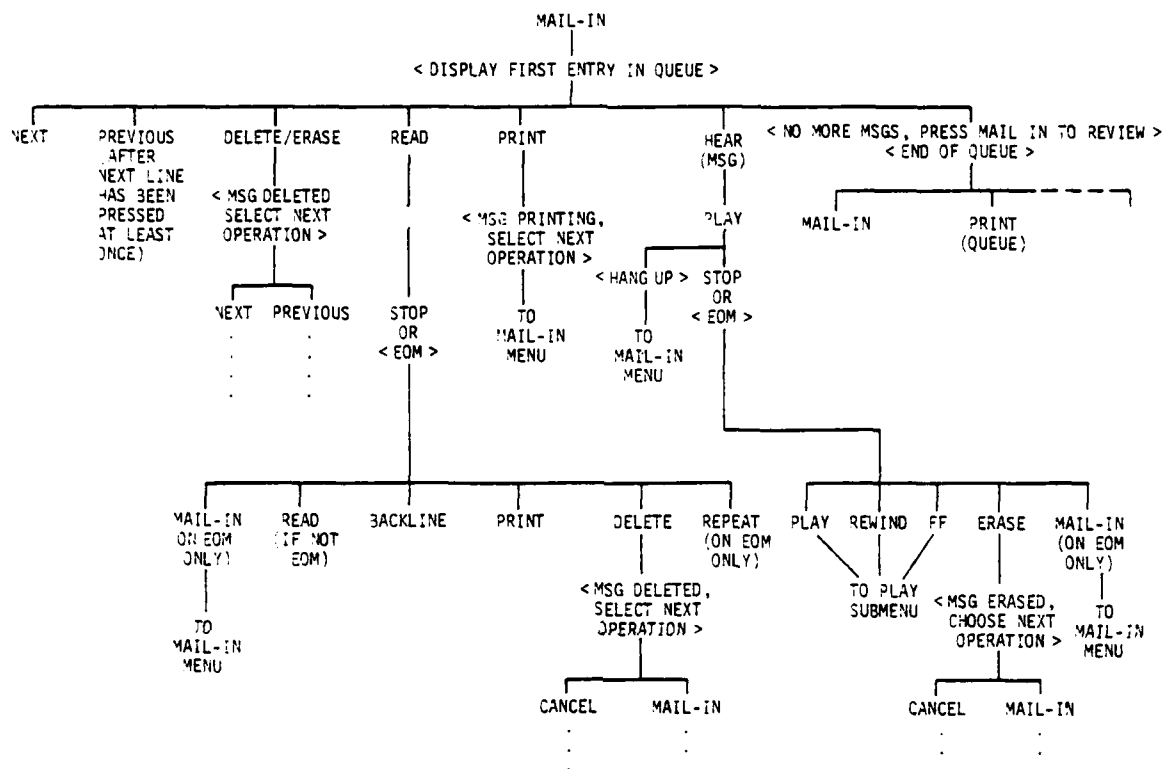MAILOUT MENU AND ASSOCIATED VARIABLE LEGEND HIERARCHY.

2-18

FIGURE 2-5.
MAILIN STATE TRANSITION DIAGRAM

again. He can browse through the remaining entries in the queue with the
help of user controls (displayed on the variable legend menu) available
to him at that point. There are several points during the course of
message selection and viewing (or listening) that the user can delete or
erase the message. The user can, if he wishes, print either a selected
text message or the list of messages at suitable points within the MAILIN
function hierarchy (see Figure 2-6). If a seen or heard message is not
deleted by the user, it will automatically be deleted after a period of
24 hours. A sample interaction of the MAILIN function is given in
Appendix B.

2.4.3   DIRECTRY Function. The DIRECTRY function of the MAILPHONE allows
the user to "directory-dial," i.e., search the on-line directory for the
telephone number of the callee and then automatically place the call when
the user presses "DIAL," with the callee's name showing in the display.
The DIRECTRY function also allows the user to edit his on-line directory,
i.e., add, delete or modify directory entries. For this purpose, the
edit functions available on the keyboard for text generation can be used.
In addition, DEL(ETE) LINE and INS(ERT) LINE variable legend function keys
are provided to the user to facilitate deletion or insertion of an
entire line via a single function keypress. (Note that delete and insert
keys, DEL and INS on the keyboard, operate on a character-by-character
basis.) The DIRECTRY function state transition diagram is given in
Figure 2-7. The variable legend hierarchy is given in Figure 2-8.

2.4.4   EXTRAS Function. The EXTRAS function of the MAILPHONE is devoted
to offering subsidiary incentives to get a first-time user involved with
the operation of the MAILPHONE. The EXTRAS function state transition
diagram is given in Figure 2-9. The prototype system offers a fun and
game package in addition to allowing the user to modify specific MAILPHONE

```
                                        MAIL-IN
                                           |
                               < DISPLAY FIRST ENTRY IN QUEUE >
    _____
    |        |           |          |         |                |                                      |
  NEXT    PREVIOUS   DELETE/ERASE   READ     PRINT            HEAR        < NO MORE MSGS, PRESS MAIL IN TO REVIEW >
          (AFTER                                             (MSG)                  < END OF QUEUE >
          NEXT LINE    < MSG DELETED                                    _____
          HAS BEEN     SELECT NEXT            < MSG PRINTING,  PLAY     |                 |                  |
          PRESSED      OPERATION >            SELECT NEXT       |      MAIL-IN          PRINT
          AT LEAST                            OPERATION >    < HANG UP > STOP           (QUEUE)
          ONCE)           |                                            OR
                      _____                    |         < EOM >
                     NEXT  PREVIOUS               TO            |
                      .      .                  MAIL-IN        TO
                      .      .                   MENU        MAIL-IN
                      .      .       STOP                     MENU
                                     OR
                                   < EOM >

    _____    _____
    |           |          |          |         |           |          |        |        |        |                |
  MAIL-IN     READ      BACKLINE     PRINT     DELETE     REPEAT      PLAY    REWIND     FF      ERASE           MAIL-IN
  ON EOM    (IF NOT                            (ON EOM                                                          (ON EOM
  ONLY)       EOM)                             ONLY)                                                             ONLY)
                                            < MSG DELETED,              TO PLAY     < MSG ERASED,
    |                                        SELECT NEXT               SUBMENU      CHOOSE NEXT                   TO
   TO                                        OPERATION >                            OPERATION >                 MAIL-IN
  MAIL-IN                                                                                                        MENU
  MENU                                    _____                        _____
                                         CANCEL      MAIL-IN                    CANCEL      MAIL-IN
                                           .           .                          .           .
                                           .           .                          .           .
                                           .           .                          .           .
```

    <HANG UP> OR <CLICK CRADLE> AT ANY POINT DURING HEAR
     MSG RETURNS TO MAILIN MENU
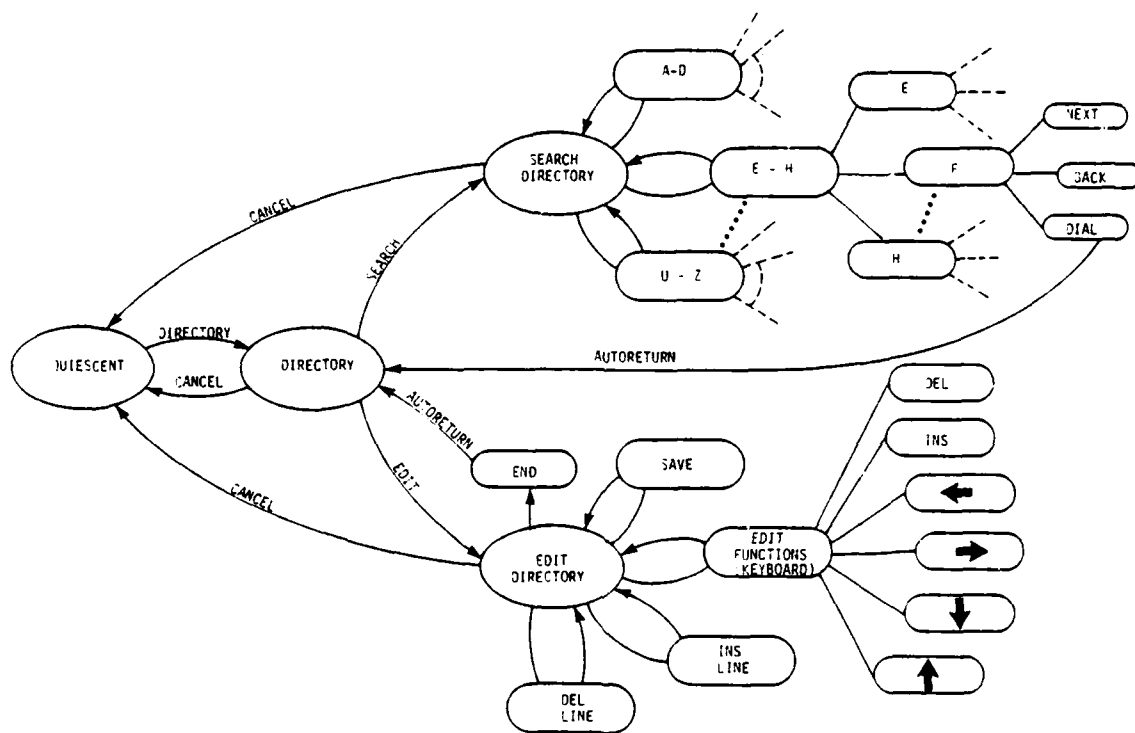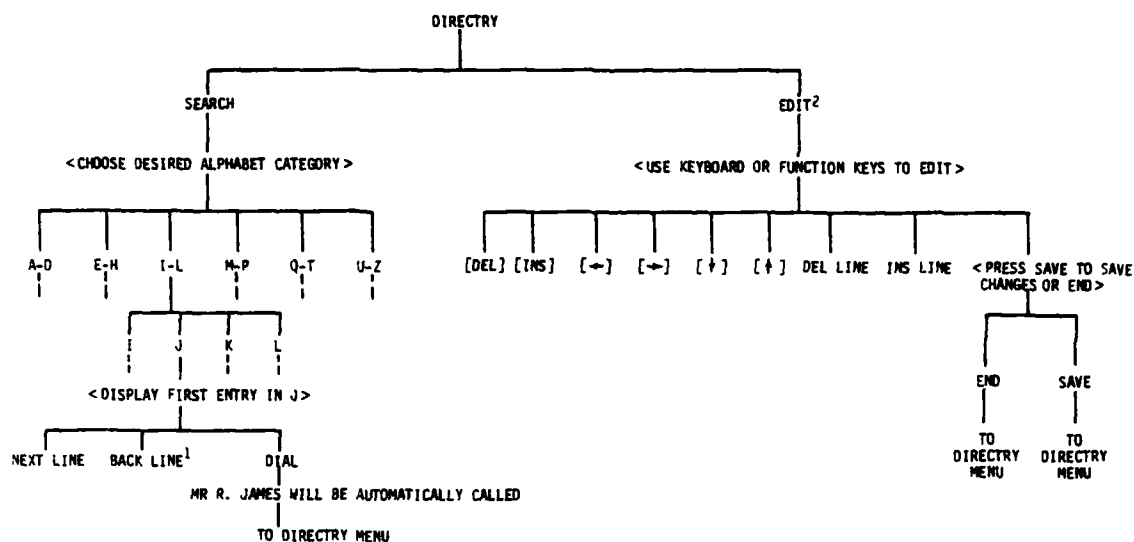
    FIGURE 2-6.
    MAILIN VARIABLE LEGEND HIERARCHY

FIGURE 2-7.
DIRECTORY STATE TRANSITION DIAGRAM

DIRECTRY

SEARCH

EDIT[2]

<CHOOSE DESIRED ALPHABET CATEGORY>

<USE KEYBOARD OR FUNCTION KEYS TO EDIT>

A-D   E-H   I-L   M-P   Q-T   U-Z

[DEL] [INS] [←] [→] [↓] [↑] DEL LINE INS LINE <PRESS SAVE TO SAVE
                                                       CHANGES OR END>

I   J   K   L

<DISPLAY FIRST ENTRY IN J>

END   SAVE

NEXT LINE   BACK LINE[1]   DIAL

TO   TO
DIRECTRY   DIRECTRY
MENU   MENU

MR R. JAMES WILL BE AUTOMATICALLY CALLED

TO DIRECTRY MENU

[1]After next line has been used once

[2]All entries in edit submenu that have box brackets
are edit keys on the keyboard

FIGURE 2-8.
DIRECTRY FUNCTION MENU HIERARCHY
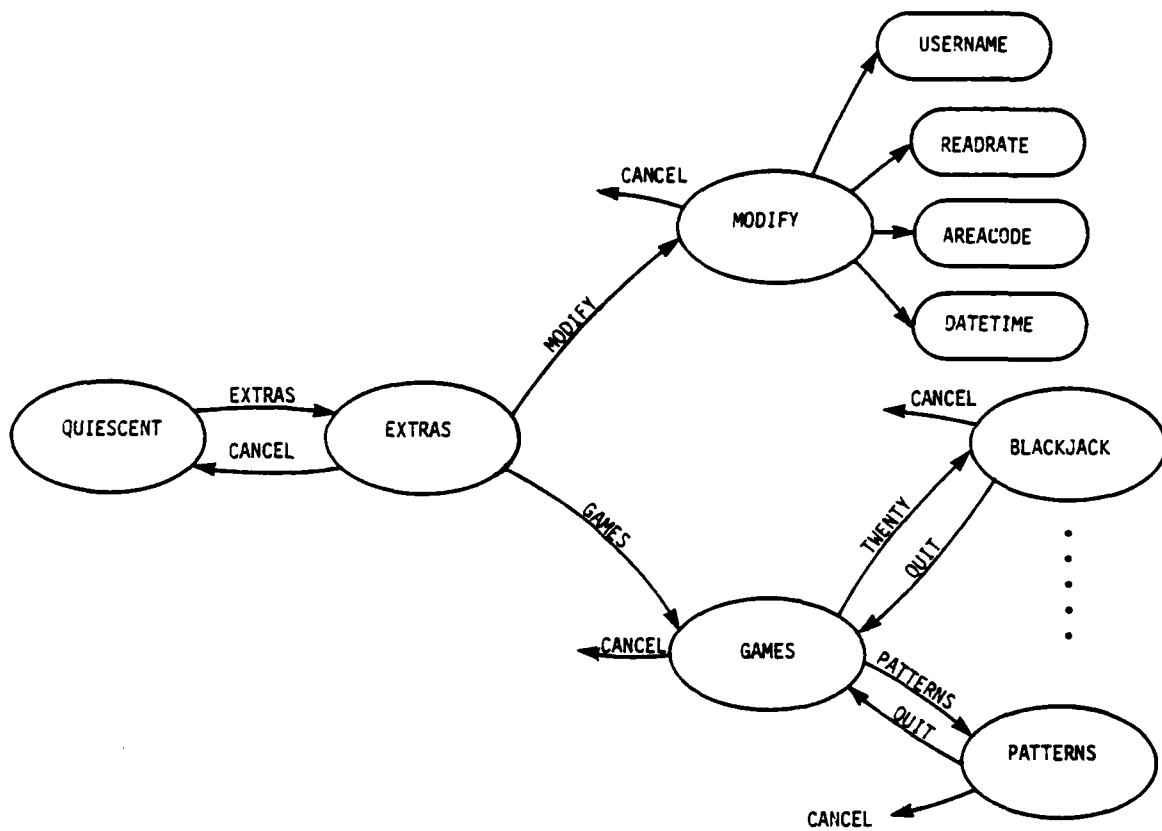
FIGURE 2-9.
EXTRAS STATE TRANSITION DIAGRAM

features such as message presentation rate, user name, number of redials, and current time. The games implemented in the prototype include Blackjack (Twenty-1) and Patterns. In the following paragraphs, the MAILPHONE implementation of each of these two games will be discussed.

Blackjack (Twenty-1) Implementation. Blackjack (Twenty-1) will be one of the games available in the menu under the EXTRAS function. In the MAILPHONE version of Blackjack, the MAILPHONE user is the only player against the dealer. The objective of Blackjack is to beat the dealer's total without going over twenty-one. On each hand after placing his bet, the MAILPHONE user (player) may get another card (a hit), stand (or hold), split a hand in the event two identical cards were dealt to him or double down. Also, the dealer will ask (via the variable legend menu) for an insurance bet if he has an exposed ace. Cards will be automatically reshuffled as the 51st card is reached.

The possible outcomes and the associated monetary consequences are given in Table 2-3.

TABLE 2-3

WIN/LOSS CONSEQUENCES VERSUS GAME OUTCOME

OUTCOME	WIN/LOSS
Tie	Even
Dealer has blackjack	Lose amount of bet
Player has blackjack	Win 1·5 x amount of bet
Dealer has higher score	Lose amount of bet
Player has higher score	Win amount of bet

The possible conditions and associated betting options are given in Table 2-4.

TABLE 2-4

SPECIAL BETTING OPTIONS

CONDITION	BETTING OPTION
Player has nine, ten or eleven; dealer and player both have low card (2-6)	Player can double bet and take only one more card
Player has a pair	Player can split cards and play two hands
Dealer has an ace showing	Player can get insurance*

The possible outcomes that can occur after the player has bought insurance and the associated monetary consequences are given in Table 2-5.

TABLE 2-5

WIN/LOSS CONSEQUENCES AFTER BUYING INSURANCE

CONDITION	WIN/LOSS
Dealer has blackjack	Even
Dealer wins without getting 21	Player loses bet plus insurance, i.e., 1·5 x amount of bet
Player wins	Player wins bet but loses insurance; thus, net winning is 0·5 x amount of bet

---

*Insurance amount is one-half the amount of the bet.

The variable legend menu is shown is Figure 2-10 and the associated sample interactions are enclosed. A sample interaction of the Twenty-1 game is provided in Appendix C.

Patterns Implementation. Patterns is a memorization game. The object of the game is to memorize and reproduce the sequence of flashing L.E.D.'s by pressing the associated function keys. There are three levels of difficulty that the user can select: easy, medium and hard. The easy level consists of reproducing four sequential flashes, while the medium and hard levels consist of reproducing six and eight sequential flashes, respectively. A sample of user interaction for Patterns is provided in Appendix D.

2.4.5 QUIKDIAL Function. The QUIKDIAL function is an executive telephone function with a two-fold use. When pressed after obtaining a busy signal on a manual dial, it invokes redialing of the busy number. The number of redials and duration between each redial can be set under the MODIFY subfunction under EXTRAS, however, the prototype will not possess these features. If pressed after entering the directory code or name of the intended recipient, it serves as a "speed dialer." A single L.E.D. indicator, at the bottom of the front panel lights up each time the dialing operation is in progress. The QUIKDIAL function state diagram along with manual telephone dialing is provided in Figure 2-11.

2.4.6 STATUS Function. The purpose of the STATUS function is to provide the user with specific diagnostic or maintenance information to rectify the problem associated with a lit CHECK STATUS L.E.D. For instance, when the blank space for recording an audio tape approaches a certain minimum level (duration), a warning is displayed to the MAILPHONE user requesting the user to selectively erase audio messages from the MAILIN queue.
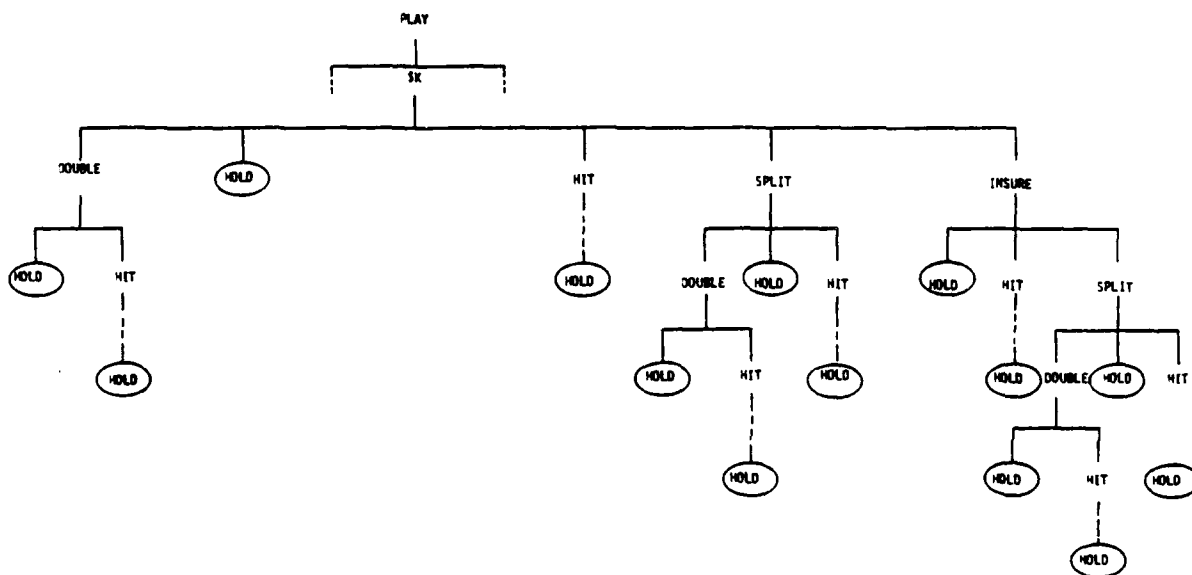
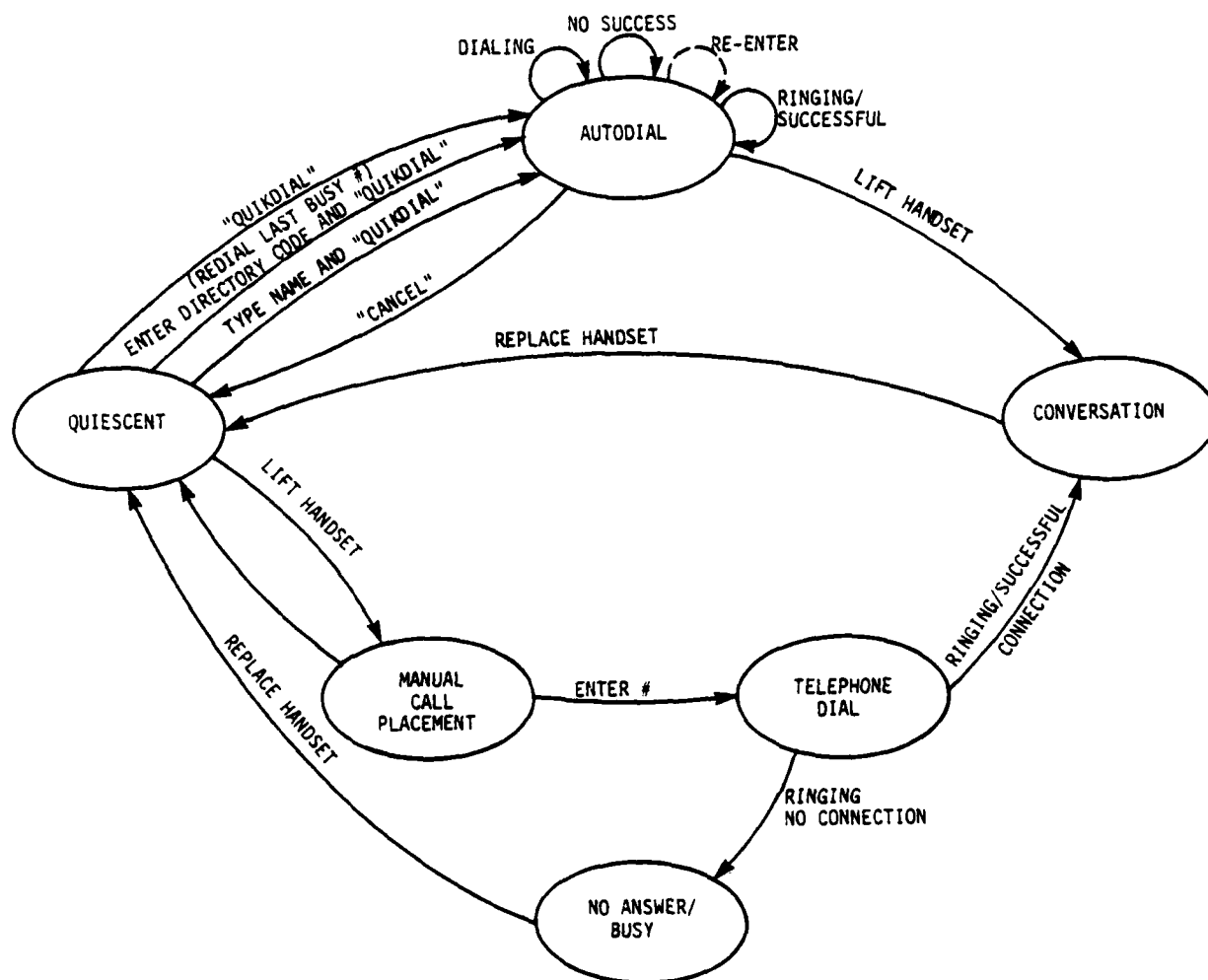FIGURE 2-10.
VARIABLE LEGEND MENU FOR BLACKJACK GAMEPLAY

FIGURE 2-11.
QUIKDIAL FUNCTION STATE TRANSITION DIAGRAM

2-29

2.4.7 <u>HELP Function and System Prompts</u>. As discussed earlier, the casual
user cannot be expected to remember a system's details over long periods
of time. Consequently, it is necessary that at each point when the user
has to perform some action, the possible choices are always available or
easily accessible to him. It is equally important to recognize that there
is little value in initial training which includes substantial indoctrination
in the details of system usage -- rather, it is important to instill a sound
understanding of the system. Many errors in practical use arise from a
mismatch between the system and the user's model of it. Since this class
of user may not tolerate much training, it is best to expose him to that
which is essential and retained most easily. Therefore, initial instruction
should be a short and clear indoctrination in the principles of the interface.
In the case of the MAILPHONE, it is important to primarily orient the user
in the MAILPHONE function state space by identifying the options open to
him and then guide him through the entire transaction associated with the
selection of each option. To this end, the MAILPHONE is provided with a
HELP function. The HELP function orients the MAILPHONE user in the function
state space by displaying to the user the possible electronic mail handling
functions the user can perform at any time. The variable legend menu and
the displayed system prompt in response to user function key selection
subsequently guide the user to the logical conclusion of each transaction.

The HELP function is provided at every level of the MAILPHONE functional
hierarchy. At the top-most level, it introduces the MAILPHONE user to the
system capabilities and associated functions. At the intermediate levels,
it orients the user by reminding him of the various options open to him
at the current node in the function state space.

The MAILPHONE makes it clear to the user when it is his turn to make entry
by issuing a suitably designed unambiguous prompt. A side benefit of the
system prompt is that it reassures the user of where his particular action
fits in the progress of the man-computer dialog. The latter is a distinct

advantage since a casual user can easily lose track of his progress because of his relative unfamiliarity with the system. Parsons (1972) makes this point after studying the results of many man-machine system related experiments:

> *"When an operator has to keep shifting between different*
> *task elements, his performance is aided by displays which*
> *indicate what he has done and should do in each instance.*
> *Otherwise, his short term memory becomes overburdened."*

Situations are bound to arise, when a user, in order to select from among the choices offered by the system, requires more information that is currently displayed to make the selection. The user may have forgotten an earlier prompt, be uncertain of the meaning or consequence of some choice, or want to explore a little first. Ideally, it should be possible to suspend the current state, find out the information needed, and return to the original state. The mechanism for doing this needs to be simple (easy to remember) and consistently applicable in whatever state the system is. The HELP function provides precisely this capability. Upon pressing HELP, the displayed variable legend menu remains unaltered. The system's response to HELP appears in place of the previously displayed prompt. The user can then continue on from the current state by either making an appropriate selection from the displayed variable legend menu or typing on the keyboard.

2.4.8 <u>CANCEL Function</u>. The CANCEL function is provided at every level of the functional hierarchy to abort (discontinue without saving) any ongoing activity and return to the QUIESCENT state. In the QUIESCENT state, it can be used to turn off the redial-last-busy-number capability of the QUIKDIAL function.

3. PROTOTYPE SYSTEM DESIGN

The MAILPHONE electronic hardware functionally consists of two main units: the Desk Unit and the Control Unit. The Desk Unit is the visible part of the system and functions as the primary interface to the user. The Control Unit, located remotely from user view, houses the main system computer, audio cassette recorder (ACR), MODEM and associated electronics, and dual floppy disks (see Figure 3-1). The Control Unit initiates all software processes based on both user inputs (from the Desk Unit) and other peripheral inputs such as incoming messages detection by the MODEM. The Control Unit-Desk Unit Interface communication is accomplished using the serial RS-232 interface hardware protocol. This form of communication allows the Control Unit to be remotely isolated from the Desk Unit. These two units along with the thermal printer comprise the MAILPHONE system.

The MAILPHONE is equipped with two telephone lines; one for live calls and the other dedicated to electronic mail. The live call line can be directly switched to the handset while the other line connects to the computer via the MODEM. The main reason for having a separate line dedicated to live calls is to ensure that a digital call cannot be intercepted by a receptionist or secretary who has no way of distinguishing between a live caller and a digital call when the phone rings. This situation is likely to occur quite frequently if all calls came in on a single line to a multi phone line environment in which a receptionist or secretary always answers the call first prior to "buzzing" the executive.

3.1 Desk Unit

The primary function of the Desk Unit is to interface with the MAILPHONE user. This user interface is characterized in terms of user inputs and system outputs defined in Table 3-1.
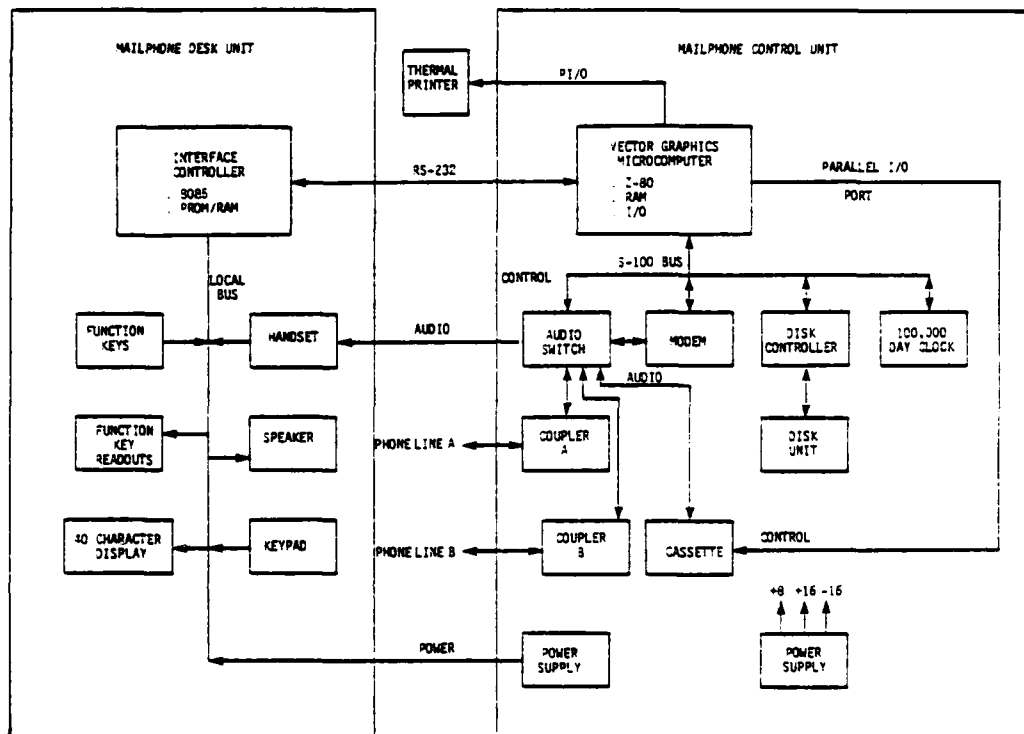
FIGURE 3-1.
MAILPHONE ORGANIZATION

TABLE 3-1

DESK UNIT I/O*

INPUTS	OUTPUTS
1. Function Keys	1. 40-Character Display
2. Keypad	2. 64-Character Function Legends
3. Alphanumeric Keyboard	3. Audio Speaker
4. Handset Switch	4. CHECK STATUS/AUTODIAL L.E.D.'s

All Desk Unit inputs from the user are encoded as defined in Appendix G and sent to the Control Unit. All Desk Unit outputs (feedback to the user) are generated from commands and data received from the Control Unit.

Each of these interface devices (switches and displays) is controlled by an 8085 microprocessor and its associated electronic software. The interface between the 8085 microprocessor and the various input-output devices is described in the following subsections.

3.1.1 Alphanumeric Keyboard. The 53-character alphanumeric keyboard is configured as a 5 X 12 matrix of contact switches such that as each column is enabled, i.e., set to a logic 1 by the 8085, the rows can then be input to the microprocessor and the closure of a switch contact can then be detected. For individual keyboard position assignments and port addresses refer to Figure 3-2. Two switches on the keyboard, designated "SHIFT" and "CTL" (control) are read from another address port (1BH), bits 0 and 1, and require no column drive output by the microprocessor.

3.1.2 Keypad and Function Keys. The 12-position touchtone keypad along with the 8 function keys are configured in a 5X4 matrix of switches similar in layout to the keyboard switches. The column drives (microprocessor output port) are the 5 least significant bits of the column address port (10H) and the row inputs are the 4 least significant bits of the row address port (19H). Figure 3-3 gives the keypad switch position (1-9, #, *) along with the function switches (FS0-FS7) positions and associated row/column assignments.

*The Control Unit which is both an input and output port for the Desk Unit does not interface with the user.
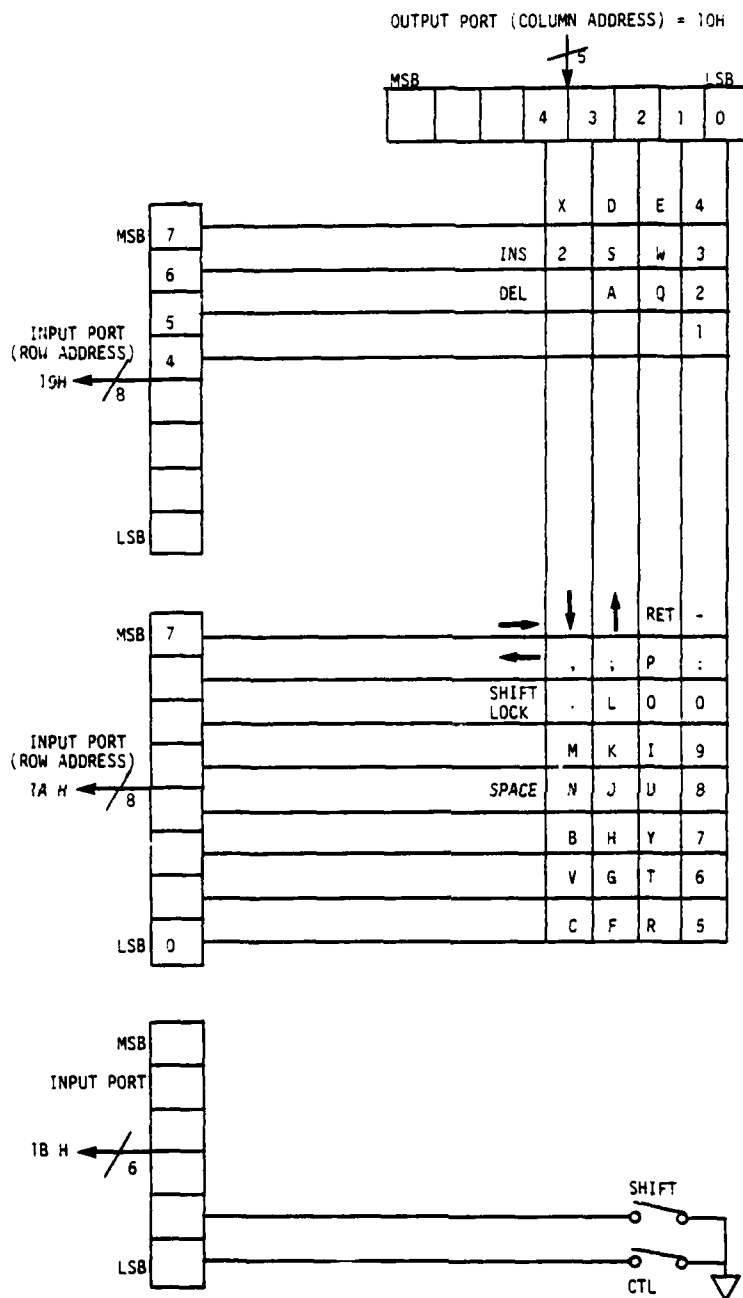
3-3

OUTPUT PORT (COLUMN ADDRESS) = 10H

			4	3	2	1	0
MSB / LSB

			X	D	E	4
		INS	2	S	W	3
		DEL		A	Q	2
						1

INPUT PORT (ROW ADDRESS) 19H /8

MSB 7
6
5
4
LSB

			↓	↑	RET	-
			,	;	P	:
		SHIFT LOCK	.	L	O	0
			M	K	I	9
		SPACE	N	J	U	8
			B	H	Y	7
			V	G	T	6
			C	F	R	5

INPUT PORT (ROW ADDRESS) 1A H /8

MSB 7
LSB 0

INPUT PORT 1B H /6

MSB
LSB

SHIFT
CTL

FIGURE 3-2.
KEYBOARD MATRIX/MICROPROCESSOR INTERFACE CONFIGURATION
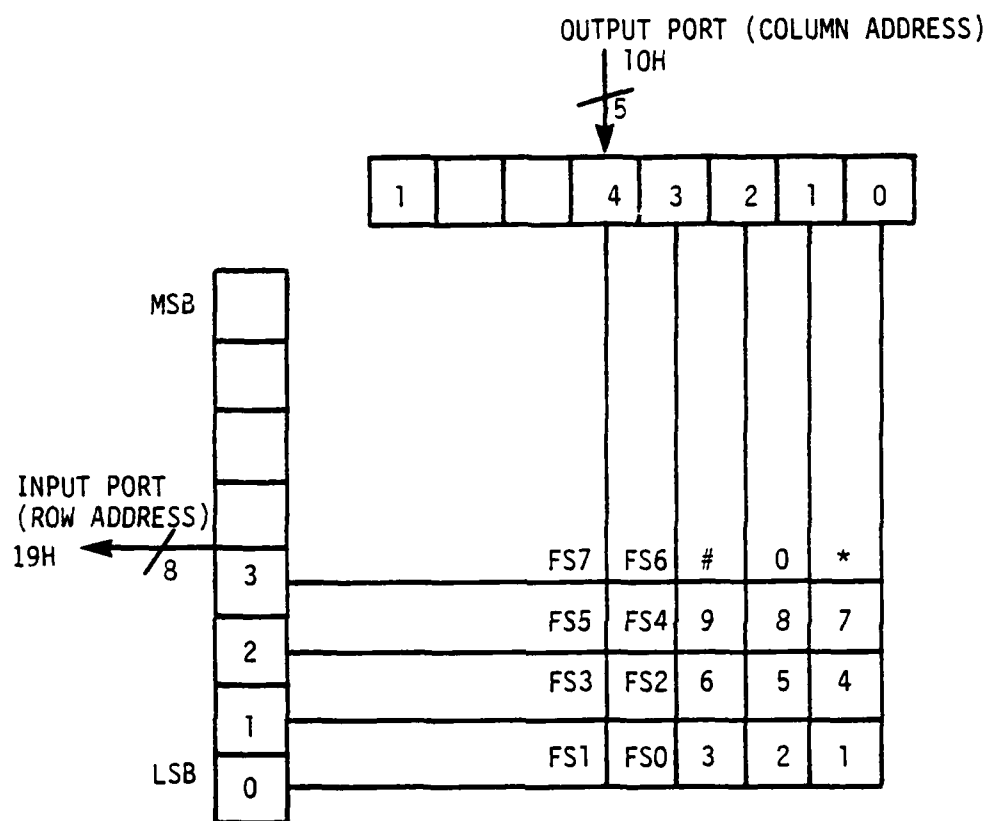
FIGURE 3-3.
KEYPAD ROW-COLUMN ASSIGNMENT

3.1.3 Displays. The Desk Unit displays are viewed by the user as a
single line of 40 characters along with 8 lines of 8 characters associated
with each of the function key legends. All characters are displayed in
a 5X7 dot matrix configuration (HP 2001). The row information for all
104 characters (40 + 8 X 8) is loaded into the display output port
location (H) and the 5 columns for all of the 104 characters are multi-
plexed at a 4 millisecond rate. Thus all 5 columns for the 104 characters
are refreshed at a 20 millisecond rate. This timing is critical for a
flicker-free display. An interrupt is generated to the 8085 microprocessor
at the rate of 25 hertz from a standard one-shot timing circuit. This
interrupt activates the refresh processing cycle for the displays.

3.1.4 Handset Switch. The handset switch is a single pole switch read
as an input to the microprocessor from the handset cradle as the handset
is picked-up by the user. The input port address for this switch is 31H
and the most significant bit of this port is used by the microprocessor
for the switch closure indication.

3.2 Control Unit

The Control Unit performs the function of the MAILPHONE system controller.
It interfaces and controls the following system hardware devices:

(1) MODEM/Coupler.
(2) Audio Cassette Recorder.
(3) Audio Switch.
(4) Thermal Printer.
(5) Floppy Disk.
(6) Desk Unit.
(7) 100,000 Day Clock.

All of these units, with the exceptions of the Desk Unit and Printer,
are housed in a Vector Graphics, S-100 Bus configured mainframe along with
the microcomputer and associated interface circuitry. Additionally, the

Control Unit houses the power supply for all internal electronic hardware
and for the Desk Unit. Refer to Figure 3-1 for the Control Unit inter-
connect diagram.

Control Unit Fabrication. The Control Unit is constructed using the
Vector Graphics mainframe which includes the following:

    (1)   S-100 bus motherboard (18 card slots).
    (2)   Power supply.
    (3)   Mini Floppy drive.
    (4)   Air cooling Rotran Whisper fan.

Added to this mainframe are the following components which constitute the
functional MAILPHONE Control Unit hardware:

    (1)   Z-80 CPU.
    (2)   65K dynamic RAM.
    (3)   PROM/RAM board.
    (4)   I/O Interface.
    (5)   80 X 24 memory mapped video board.
    (6)   MODEM.
    (7)   Disk Controller.
    (8)   100,000 Day Clock.
    (9)   Desk Unit power supply.
  (10)   Audio Switching Module
  (11)   Couplers (2).
  (12)   Audio Cassette Recorder.
  (13)   Dual Floppy Disks.

Refer to Figure 3-4 for a pictorial sketch of the Control Unit hardware.
The first 8 items listed above are S-100 bus compatible cards that can
be inserted into any of the 18 card slots provided by the Vector Graphics
motherboard. These functional cards are standard "off-the-shelf" type
boards and when configured together form a basic microcomputer system.
Data sheets are provided in Appendix F for the 100,000 Day Clock,
Cassette, MODEM, and Desk Unit power supply.

Labels on figure:

ROTRON WHISPER FAN

Desk Unit Power Supply
Z80 CPU
DISK CONTROLLER
I/O
RAM
PROM / RAM
VIDEO BOARD
REALTIME CLOCK
MODEM
AUDIO SWITCHING MODULE

POWER SUPPLY

DISKS

COUPLER A

COUPLER B

AUDIO CASSETTE RECORDER
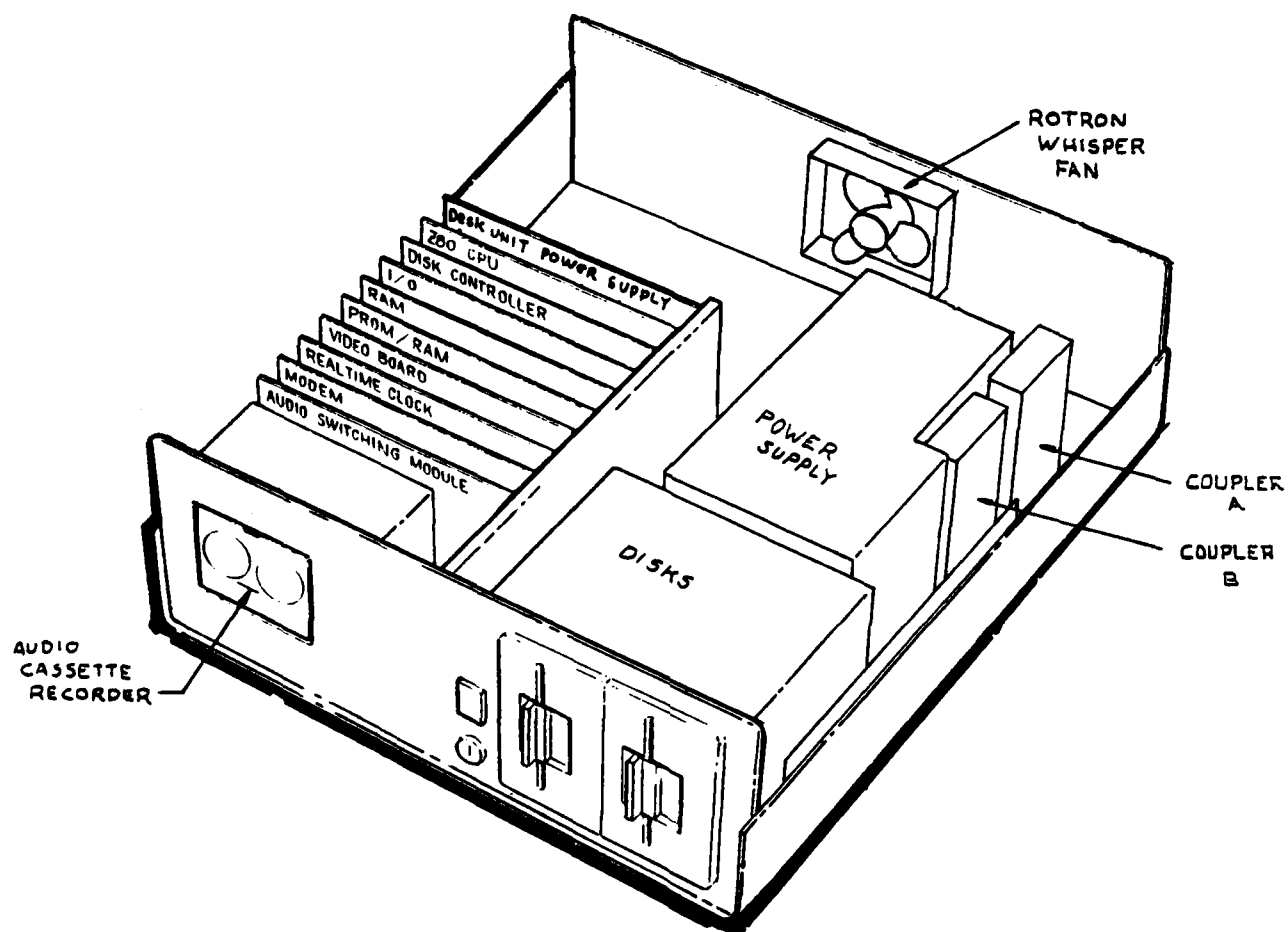
FIGURE 3-4.
CONTROL UNIT LAYOUT

The Desk Unit power supply and the custom Audio Switching module are mounted on S-100 bus compatible cards and inserted into the S-100 bus motherboard as shown in the figure. The front panel of the Vector Graphics mainframe has been modified to accommodate the Audio Cassette Recorder (ACR). The ACR and its own power supply are mounted inside the mainframe and attached to the front panel. A slot cut in the front panel permits easy access to the cassette tape. The ACR unit extends over the front four S-100 bus card slot locations which have been removed for this unit.

The two phone line couplers are mounted directly to the Vector Graphics mainframe as shown in the figure. The dual floppy disk drives are mounted to the mainframe. The slots are provided by the Vector Graphics mainframe front panel.

3.2.1 <u>Microcomputer</u>. The Vector Graphics microcomputer consists of the Z80 microprocessor, associated memory, S-100 bus interface logic and various input/output (I/O) ports. This configuration is particularly suitable for the MAILPHONE system controller in that event-driven, real-time processing can be accomplished using hardware-generated vectored interrupts to drive functionally partitioned software control programs.

The Vector Graphics microcomputer system provides the following, in addition to the Z80 microprocessor:

    (1)   *64K* words of random access memory (RAM).*
    (2)   Two 8-bit parallel I/O ports.
    (3)   One serial RS-232 compatible I/O port.

---

*K = 1024

(4) Dual floppy disk controller.

(5) S-100 bus motherboard.

The RAM is used for software programs and data bases. One parallel I/O port is used for the Audio Cassette Recorder (ACR) interface, while the second is used for printer communication. The RS-232 serial port provides microprocessor interface to dual floppy disks used for MAILPHONE software secondary storage. The S-100 bus motherboard provides the communication interface between the S-100 bus compatible hardware modules and the microprocessor. These include (a) Disk Controller, (b) MODEM, (c) 100,000 Day Clock, and (d) Audio Switch. Each of these peripheral devices are discussed in the following subsections.

3.2.2 MODEM/Coupler. A MODEM is a device that converts digital data from a computer, or terminal to a modulated carrier waveform required by the communication channel. At the other end of the link, the demodulator of a second MODEM reconverts the analog signals to digital outputs. Use of MODEMs on the dial-up facilities of the telephone company require that the user interface his MODEM to the line with a coupler device. The MAILPHONE uses an FCC registered protective coupler. Its purpose is to protect the computer user and telephone network from the harmful effects of high voltage spikes and excessive signal levels. It also insures that the telephone billing equipment will properly register and time the calls.

The MAILPHONE system MODEM hardware is configured as depicted in Figure 3-5. This figure shows two couplers (A & B) for interfacing with two phone lines. Coupler A is used in conjunction with the MODEM for the transmission of both audio and digital electronic mail. Coupler B is used for live audio calls, i.e., normal telephone communication. The

```
                    MODULATED
                     DIGITAL
  S-100 BUS    ┌─────────┐   ←────    ┌─────────┐    AUDIO SIGNALS
  ◄──────────► │  MODEM  │   DATA     │ COUPLER │   ◄──────────────►
               └─────────┘  OR AUDIO  │    A    │   TO PHONE LINE A
                              ────►    └─────────┘


  TO HANDSET      AUDIO       ┌─────────┐    AUDIO SIGNALS
  OR CASSETTE  ◄──────────    │ COUPLER │   ◄──────────────►
                   ────►      │    B    │   TO PHONE LINE B
                             └─────────┘
```
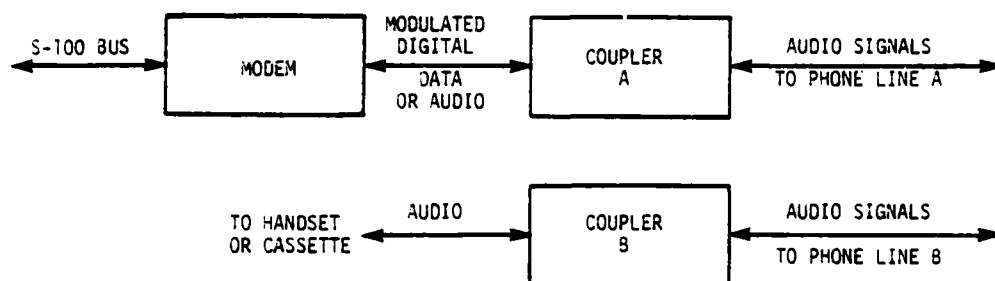
FIGURE 3-5.
MAILPHONE MODEM/COUPLER CONFIGURATION

3-11

control that determines which coupler ought to be used is performed by the Control Unit through a device termed "AUDIO SWITCH" described under Section 3.2.3.

The MODEM used in the MAILPHONE system is the D.C. Hayes Associates, S-100 bus compatible MICROMODEM 100. This MODEM possesses the following features:

(1) FSK modulation technique.

(2) 300 baud maximum transfer/receive rate (30 characters/sec.).

(3) Full duplex operation (simultaneous two-way communication).

(4) Carrier detect indication (used to detect "phone-answer" at the receiving phone).

(5) Lost carrier detect (indication that receiving phone is back on-hook).

(6) Phone ring indication.

(7) Transmit/receive registers full (used to synchronize hardware and software data transmission and reception).

(8) 50 Ms time up (used for timing during dial).

Items 4 through 8 also provide S-100 bus type interrupts to the microcomputer system for rapid context switching in a real-time environment or system configuration.

3.2.3 Audio Switch. The Audio Switch is an S-100 bus configured module, controlled by the microcomputer, which performs several functions in the MAILPHONE system related to the transfer of audio signals between various system modules. All audio signals are routed through a switch network of the Audio Switch module to one of several destinations. These include

the ACR, Handset, MODEM, and two Couplers. Additionally, the Audio Switch module provides the digital control interface to the ACR, Coupler B and generates the touchtone signals for user feedback while dialing.

The Audio switching function performed by this module is represented logically in Figure 3-6. The Audio Switch module accepts software commands (issued by the microcomputer) that specify switch openings and closures thereby interconnecting two or more audio devices. The switching network has two audio buses, B1 and B2. Any individual switch connects an audio device to one of the audio buses. A typical connection between two devices is made by the microcomputer with the setting of two bits in the output command byte. The correspondence of actual switches to audio devices may be determined from the logic drawing of Figure 3-6. Table 3-2 defines a matrix of allowable settings for the commonly used connection pairs. Each column entry in the table represents a connection of that device with the device in a given row. The entry of B1 or B2 indicates which of the two audio buses in the switch network is used for that connection (refer to Figure 3-6) while an "X" indicates that no connection is possible.

Table 3-3 presents a list of the allowed (i.e., connectable) combinations of audio devices.

The touchtone generator provides audible feedback to the MAILPHONE user through the handset when keys on the telephone keypad are pressed. The tones are generated by a special purpose electronic chip controlled by seven bits from the microcomputer (output port 62H). The specific combinations of bits that produce tones are indicated in Table 3-4.

3-13
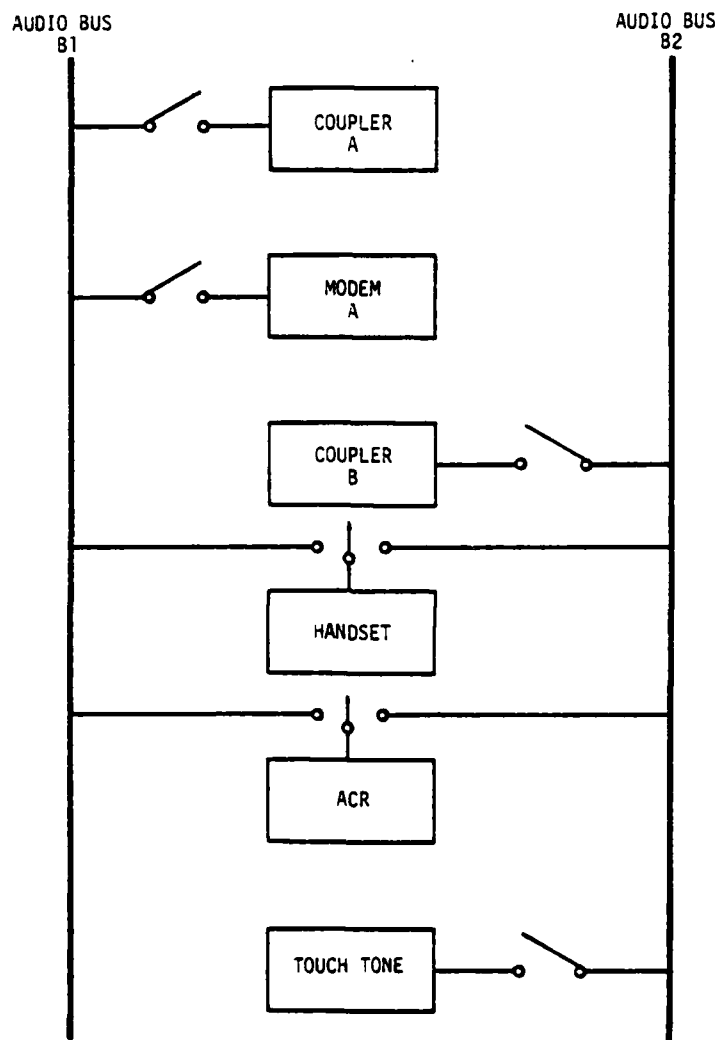
FIGURE 3-6.
AUDIO SWITCH MODULE SWITCHING NETWORK LOGIC DIAGRAM

TABLE 3-2

AUDIO SWITCH MODULE DEVICE INTERCONNECT MATRIX

AUDIO DEVICES	MODEM	ACR	HANDSET	TOUCHTONE
Coupler A	B1	B1	B1	X
Coupler B	X	B2[2]	B2	X
Handset	X	B2	X	B2

TABLE 3-3

AUDIO SWITCH ALLOWABLE CONNECTION PAIRS

CONNECTION PAIR	CONCURRENT CONNECTION PAIR[2]
1. Coupler A/MODEM	Coupler B/ACR[2] Coupler B/Handset Handset/ACR Handset/Touchtone
2. Coupler A/ACR	Coupler B/Handset Handset/Touchtone
3. Coupler A/Handset	Coupler B/ACR[2] Handset/ACR Handset/Touchtone

[1]Only one connection pair of those listed can be selected.

[2]Not used in the prototype system.

TABLE 3-4

TOUCHTONE GENERATOR OUTPUT CODES

KEYPAD ENTRY	OUTPUT BYTE (HEX)
1	11
2	21
3	41
4	12
5	22
6	42
7	14
8	24
9	44
�	18
0	28
#	48

The tone from the generator chip is connected into the Audio Switch module switching network as shown in Figure 3-6. The touchtone generator can only be connected to the handset.

3.2.4   Audio Cassette Recorder (ACR). The ACR used in the MAILPHONE system is the Triple I PHI-DECK recorder. This unit provides the following interface control functions to the microcomputer system.

    (1) Fast Forward.
    (2) Rewind.
    (3) Playback.
    (4) Record.
    (5) Stop.

These commands are generated from the microcomputer output port (63H) to the Audio Switch module where due to the available space the ACR interface logic is implemented. The record/playback speeds are 1-7/8 ips and the fast forward and rewind times are less than 35 seconds for a C-60 cassette.

The PHI-DECK ACR unit generates 18 interrupts per revolution of the takeup reel to the microcomputer. These interrupts are then used by the software for audio tape file management and record-head positioning.

Additionally, specific status indications are provided at the microcomputer input port (62H). These include:

    (1) End of tape/beginning of tape.
    (2) Stop.
    (3) Run.
    (4) Fast Forward.
    (5) Rewind.

3.2.5 Printer. The printer used in the MAILPHONE system is a TRENDCOM
200 high-speed intelligent printer. This device prints up to 40 characters
per second and up to 80 characters per line. The TRENDCOM 200 requires
no external power supplies. The TTL-compatible input interfaces directly
to the eight-bit parallel I/O port of the Control Unit. It is a true
intelligent printer with full line buffering, i.e., one full line of
characters accepted by the device before actual printing, and bi-directional
look-ahead printing. The contents of the buffer are printed following
receipt of a carriage return code (DDH) or upon receipt of the 81st
character. Upon one line being printed left to right, the internal micro-
processor examines the next line and selects the most efficient printing
direction, either returning to the left margin, or moving to the location
for the last character in the next line and printing it right to left.
The 5 X 7 dot matrix characters are printed in a ten character-per-inch
format. The printer incorporates a built-in self-test capability, activated
by a slide-switch inside the printer. When this switch is activated, the
unit if functioning properly continually prints a predefined message.
(Self-Test overrides the external input from the Control Unit.)

3.2.6 Power Supply. The Control Unit houses two separate power supplies.
One supplies the power for the microcomputer system, including the floppy
disks and all S-100 bus-compatible card modules. This power supply is part
of the Vector Graphics mainframe. It generates the following voltage/
current specifications:

    (1) + 8V/20A.
    (2) + 16V/25A.
    (3) - 16V/25A.

These voltages are supplies unregulated to the S-100 bus where each of
the individual card modules contain the required regulators.

The second power supply generates the regulated +5 volts (maximum current of 12 amps) used by the Desk Unit. The unit is a Power General Switching power supply with an efficiency rating in excess of 75%. This power supply is mounted inside the Vector Graphics mainframe instead of the Desk Unit in order to limit Desk Unit size and conserve space.

3.2.7 <u>100,000 Day Clock</u>. The 100,000 Day Clock is a S-100 bus compatible card module supplied by Mountain Hardware, Inc. This device is used by the MAILPHONE system for date and time information. It will keep track of time in 100 microsecond intervals, up to 100,000 days. CMOS circuitry is employed in the design of the device which allows the clock to be run off a 9-volt battery for up to four days while the Control Unit is shut down or if AC power fails. The Clock uses 15 I/O ports for the time plus one I/O port to set the interrupt function. The Clock is set by entering BCD digits one at a time at each time port. When the first digit is entered, the clock stops and then the remaining digits are entered. The Clock then starts on the first read command from the micro-computer. Table 3-6 shows the significance of each of the 16 I/O ports and the time range associated with that port. Each digit of time is made available as the microcomputer reads the proper port numbers.

3.3   <u>Control Unit-Desk Unit Interface</u>

The hardware interface between the Control Unit and Desk Unit is the RS-232 standard interface and protocol. This hardware interface is used by the software of both the units in order to communicate commands and data. Information passes from the Desk Unit informing the Control Unit of various requests made by the user and likewise, the Control Unit passes infor-mation to the Desk Unit, to indicate to the user, various states of the system in the form of displays and sounds. Appendix F gives the details and contents of the information that is transmitted and received between these two units. The objective of the design given is to minimize the amount of data on the interface, allowing for maximum processing time in both the Desk Unit and Control Unit with minimum error from the interfaces.

TABLE 3-6

100,000 DAY CLOCK PORT SIGNIFICANCE

PORT ADDRESS	PORT SIGNIFICANCE	TIME RANGE
Lowest	100 us (microseconds)	0-9
Lowest +1	1 ms (milliseconds)	0-9
Lowest +2	10 ms	0-9
Lowest +3	100 ms	0-9
Lowest +4	1 second	0-9
Lowest +5	10 seconds	0-5
Lowest +6	1 minute	0-9
Lowest +7	10 minutes	0-5
Lowest +8	1 hour	0-9
Lowest +9	10 hours	0-2
Lowest +10	1 day	0-9
Lowest +11	10 days	0-9
Lowest +12	100 days	0-9
Lowest +13	1,000 days	0-9
Lowest +14	10,000 days	0-9
Highest	Interrupt port	0-14 (0-E Hex)

4. PROTOTYPE SOFTWARE DESIGN

The MAILPHONE software is functionally partitioned between the Desk Unit and the Control Unit. Software functions associated with the Desk Unit are directly related to the user interface. These include:

(1) Display update (legends 40 character).
(2) Keyboard/keypad input processing.
(3) Function key selection.
(4) Generation of sounds (beep, click, ring).
(5) Handset on/off hook indication.
(6) L.E.D. on/off indication.

Software functions associated with the Control Unit directly control the MAILPHONE activity and general processing. The Control Unit views all other peripheral units, including the Desk Unit, as I/O devices. The following subsections describe in detail the functional software for these units.

4.1 Desk Unit Software

The Desk Unit software, executed on the 8085 microprocessor, functions as the controller of the user interface to the Control Unit. User inputs in the form of (1) function key presses, (2) keypad entries, (3) handset on-hook/off-hook condition, and (4) keyboard entries are the events that drive the execution of the Desk Unit software.

The Desk Unit software performs the real-time update of: (1) 40 character display, (2) 64 character variable legend readouts, (3) CHECK STATUS/AUTO-DIAL L.E.D. indicators, and (4) various sounds (i.e., keyclicks, beeps, rings).

The software necessary to control and respond to these interfaces is described in the following subsections. All control data required by the Desk Unit software is described in the Desk Unit-Control Unit Interface section (Section 3-3) of this document.

4.1.1   Interface Software. The Desk Unit interface software is primarily driven by the refresh time of the 104 character display (40 and 64 characters). For flicker free viewing of these displays it is necessary to refresh all of the 5 columns for all 104 characters every 20 msec. (50HZ). In other words, a column is refreshed every 4 msec. The software refresh cycle is started by an interrupt to the 8085 microprocessor every 4 msec. At the completion of the refresh cycle for a single column for all 104 characters, the Desk Unit software polls the keyboard, keypad, function switches, and handset switch for any closure indication. A switch closure condition is then encoded, as defined in the Desk Unit-Control Unit Interface section of this document, and sent to the Control Unit for further processing.

The Desk Unit software responds to both transmit and receive interrupts from the RS-232 interface of the Control Unit. The receive interrupt is an indication of data being sent to the Desk Unit from the Control Unit in the form of commands and data, as described earlier. Commands are for sounds, display control, and individual light control. Data is received for display information in the form of ASCII characters. The ASCII characters sent by the Control Unit are decoded by the Desk Unit software into their viewable 5 X 7 dot matrix font. The legends associated with the function switches are part of a fixed data base in the Desk Unit. A number that indexes into these legends is sent by the Control Unit for legend updates.

4.1.2   Data Bases. The software overhead associated with converting
one data form to a more usable standard format is performed by the Desk
Unit. This, of course, frees the Control Unit to perform the necessary
control functions for the system. In general, this conversion requires
the creation and use of fairly sizeable data bases.

The Desk Unit converts (1) keyboard switch positions as displayed on
the keyboard to ASCII characters, (2) keypad switch positions to ASCII
encoded numerics, (3) ASCII characters from the Control Unit to a 5 X 7
dot matrix representation (font), and (4) function legend index and
position information from the Control Unit to 64 character display
position and viewable legend. These data bases, along with the executable
code associated with the Desk Unit, are contained in the Desk Unit ROM.

4.2   Control Unit Software

The Control Unit software, executed on the S-100 bus configured Z-80
microprocessor-based Vector Graphics microcomputer, functions as the
MAILPHONE system controller. All user actions from the Desk Unit are
controlled and processed by the Control Unit software. All displays
and feedback to the user are also generated from the Control Unit.

The Control Unit is the focus of all events external to the MAILPHONE.
The Control Unit software is structured in a top down modular fashion
as ,shown in the functional block diagram of Figure 4-1. The System
Monitor functions as the main background processing module which responds
to all other system events (interrupts) as they occur in real-time. The
events which the System Monitor responds to are all user actions at the
Desk Unit in the form of function key presses, handset usage and keypad
and keyboard entries. Any of these actions at the Desk Unit result in a
single hardware interrupt to the Control Unit. The Control Unit System
Monitor software responds to other external system events in the form
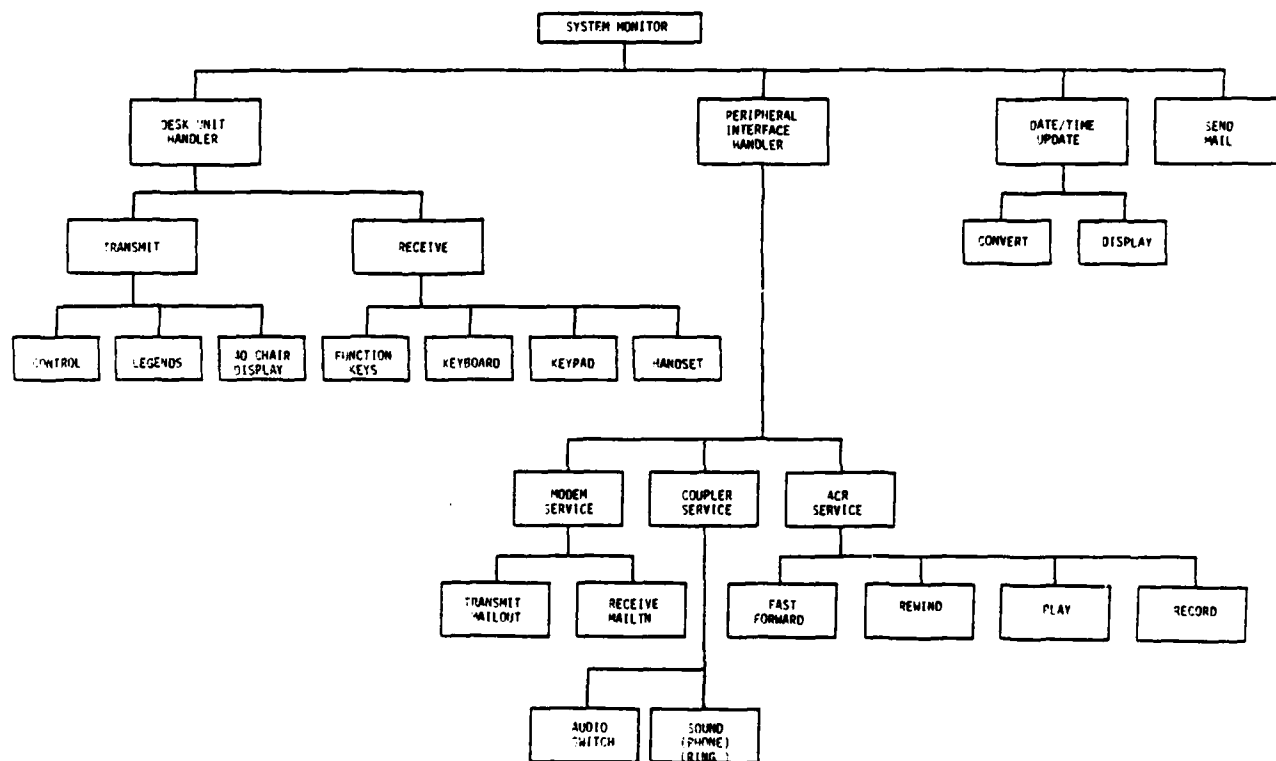
FIGURE 4-1.
CONTROL UNIT SOFTWARE FUNCTIONAL BLOCK DIAGRAM

of (1) MODEM ring, (2) Coupler ring, and (3) Audio Cassette Recorder (ACR) tape motion. These events result in one additional hardware interrupt to the Control Unit. The Peripheral Interface Interrupt handler then polls each of these devices to determine which device generated the interrupt and then vectors to the appropriate event processing function associated with that device.

4.2.1 <u>System Monitor and Interrupt Processing</u>. The Control Unit System Monitor software functions as the main idle loop for the processing of system events (interrupts). When power is turned on, the system and associated data bases are initialized and interrupts are enabled (see Figure 4-2). The system is then capable of processing external events. In the quiescent state, i.e., when no interrupts are pending, the System Monitor displays the current date and time on the 40 character display. If there is any pending mail waiting to be transmitted, the SEND MAIL function is invoked and the associated processing performed.

The System Monitor software is exited at the occurrence of any external event (interrupt) and either the Desk Unit Handler or the Peripheral Interface Handler software is entered for further processing. When the Desk Unit Handler is invoked as a result of an interrupt-generating event from the Desk Unit, the word sent to the Control Unit is used to initiate the next level of processing (see Figure 4-1). At this level, processing is performed for function key selections, keyboard entries, keypad pushes or handset ON-hook/OFF-hook indication. The software processing at each of the subsequent levels (shown in Figure 4-1) is associated with the implementation of the function state transition diagram included in Section 4.2.2.

The Peripheral Interface Handler is invoked as a result of a MODEM "ring detect," a Coupler "ring detect," or tape motion of the ACR. The correct processing is initiated as a result of polling each of these devices for
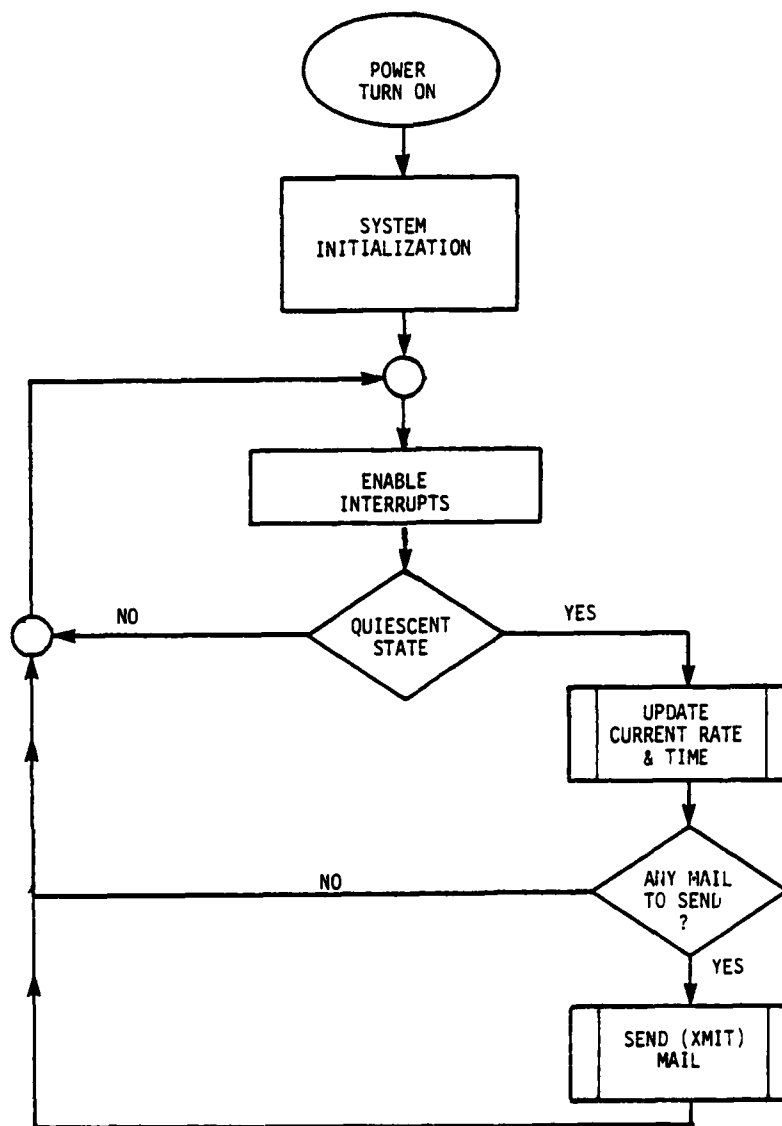
FIGURE 4-2.
SYSTEM MONITOR FUNCTIONAL FLOW CHART

determining the source of the interrupt. MODEM software processing is invoked once the "Ring Detect" status bit is set. Electronic mail reception occurs subsequently if all other required conditions are satisfied. Coupler software processing is executed when the "Ring Detect" status bit is set in response to an incoming telephone call. Depending on the MAILPHONE function state, this function either initiates the recording of the incoming call on the ACR or generates a Desk Unit "ring" associated with a normal incoming phone call. The ACR software processing is invoked as a result of any tape motion. For ease of ACR tape file management, each ACR message is limited to a one-minute segment of tape. This software processing controls both the "RECORD" and "PLAYBACK" functions for outgoing and incoming messages. Once a one-minute segment on tape has been allocated, the user is restricted to this segment under software control for any given message.

4.2.2 Function State Processing. The eight variable legend function keys provide the user with a hierarchical structure to invoke the various MAILPHONE capabilities at each functional level. The multiple levels under each top-level major function require that the function keys assume the specific meanings associated with the corresponding function legend readouts. The specific legend depends on the top-level function state selected by the MAILPHONE user and the specific level within the functional hierarchy. In order for the Function Switch Processing software to initiate the correct functional level, knowledge of the system states must be kept. The system states associated with the "MAILOUT" function are shown in the hierarchical tree structure of Figure 4-3. At each level in the structure the function keys assume the meaning associated with the next level of the tree structure.

The Function Switch Processing must perform the following sequence of tasks in response to any function key press regardless of the level within the functional hierarchy:

4-7
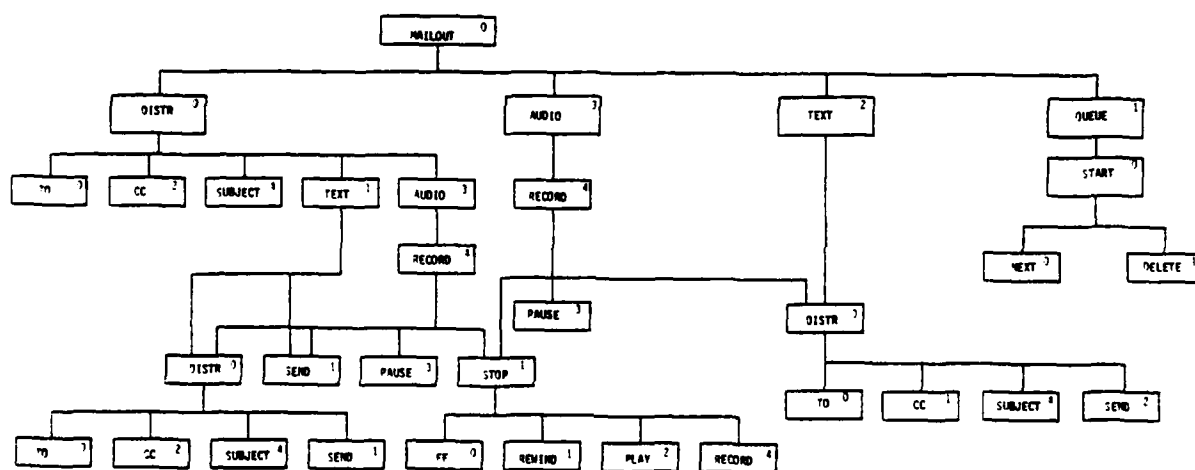
NOTE: NUMERIC IN UPPER RIGHT CORNER REPRESENTS
       THE FUNCTION LEGEND LOCATION ON THE DESK
       UNIT FOR THE FUNCTION IN THE BOX.

FIGURE 4-3.
"MAILOUT" FUNCTIONAL HIERARCHY

(1) Clear the 40 character display.

(2) Clear the function legends (64 character display).

(3) Perform the processing associated with the function switch
     pushed for the current level on the hierarchical tree
     structure.

(4) Update the function legends for the next level on the
     tree structure.

(5) Update the 40 character display for the next level on
     the tree structure.

(6) Represent the next level of function switch processing
     to allow for the next function switch to be pushed.

In order to perform each of the above tasks, the Function Switch
Processing software must maintain a data base with information about
each of the tasks unique to the processing at that level. Figure 4-4
represents the data base structure used by the Function Switch Processing
to traverse any of the hierarchical tree structures for the MAILPHONE.
When a function switch is pushed, the Function Switch Processing software
is entered with a number from 0 to 7, representing which function switch
has been selected. This is then used as an index into the Function Switch
Pointer Table (FSPT). The FSPT contains 8 address pointers to a Process-
ing Level Descriptor Table (PLDT) which is defined by the processing
function for that level and contains the necessary data for that level
of processing. The data in the PLDT provides the information to the
Function Switch processing tasks 3 through 6 listed above for each level
on the system state hierarchical tree structure. The Function Switch
Processing software, having indexed into the FSPT, will access the PLDT
for the function switch pushed and use the information in the table to:

(1) Update the 40 character display.

(2) Update the function legends.

(3) Vector to the processing function for that level.
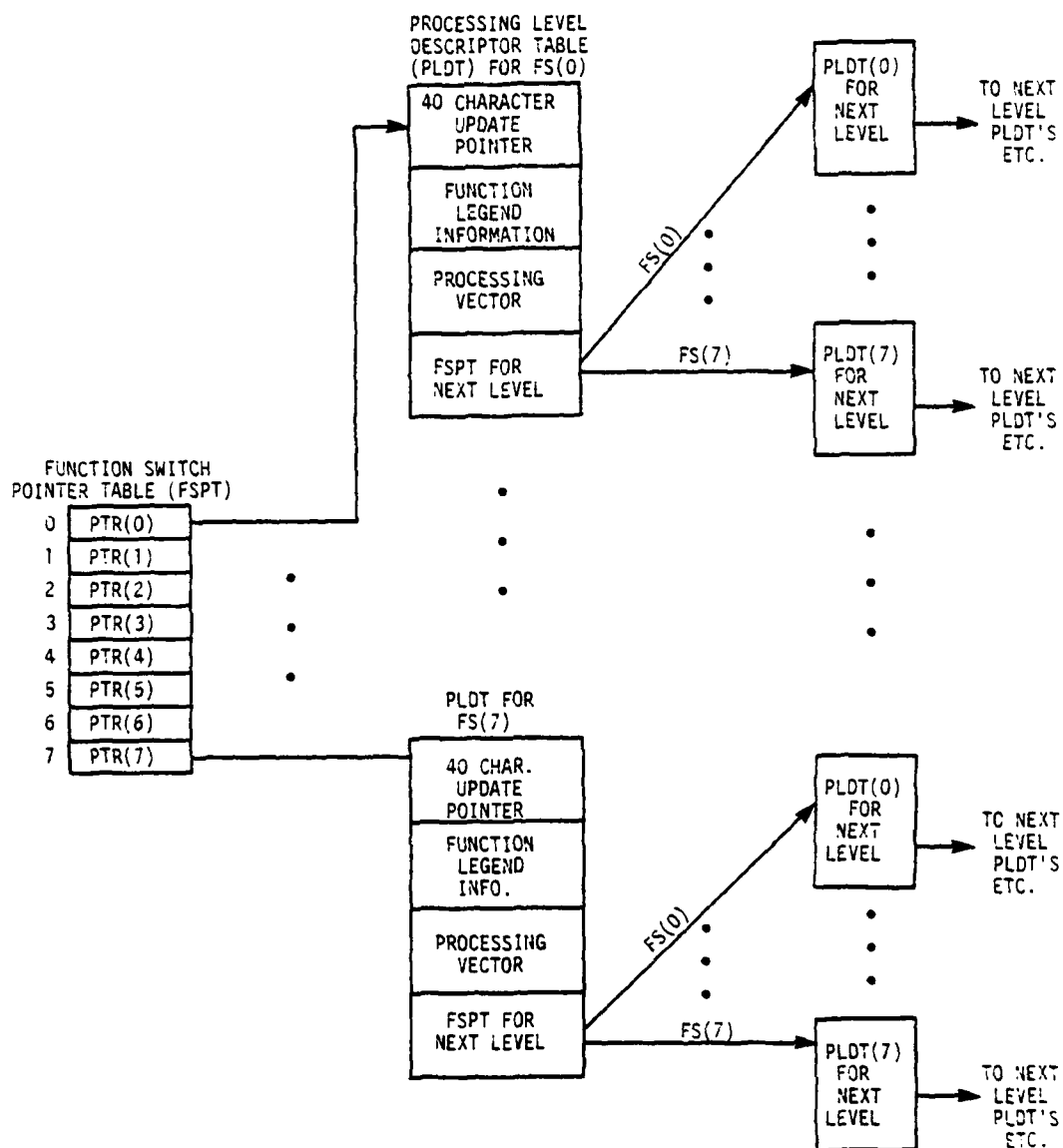
FIGURE 4-4.
FUNCTION SWITCH PROCESSING DATA BASE STRUCTURE

(4) Update the FSPT by using the data from the PLDT for
    the next level.

Figure 4-5 shows the data base content for the PLDT and Figure 4-6 shows
a representative hierarchical data base structure for the hierarchical
tree structure of "MAIL-OUT."

4.2.3 Interface Management. The various Input/Output (I/O) devices
used by the system include the following:

(1) 100,000 Day Clock.
(2) Audio Switch.
(3) Audio Cassette Recorder (ACR).
(4) MODEM.
(5) Coupler.
(6) Printer.
(7) Disk.
(8) Desk Unit.

Each of these I/O devices require interface software and specific
driver functions in order to perform their assigned functions. Each of
these devices needs to be suitably initialized when power is first applied.

4.2.3.1 100,000 Day Clock. The 100,000 Day Clock provides date and time
information for display in the quiescent state and for other timing
functions required by the system. This device is initialized when the
user inputs the correct date and time under the "MODIFY" option under
"EXTRAS." At all other times, this device is read by the software in the
units defined in Table 3-6 and converted for display to month, day, hours,
and minutes represented as ASCII characters.

```
                7            0
PLDT(i)    ┌─────────────────────┐ ⎫   POINTER TO A STRING OF 40
           │  40 CHAR DISPLAY    │ ⎬   ASCII CHARACTERS (2 BYTES)
           │    INFORMATION      │ ⎭
           ├─────────────────────┤ ⎫   FUNCTION LEGEND INDEX NO.
         ≈ │     FUNCTION        │⎬ ≈  ORDERER FOR FS(0) - FS(7)
           │      LEGEND         │ ⎭   (8 BYTES)
           │    INFORMATION      │
           ├─────────────────────┤ ⎫   POINTER TO PROCESSING ROUTINE
           │    PROCESSING       │ ⎬   FOR THIS FUNCTION LEVEL SWITCH
           │     VECTOR          │ ⎭   (2 BYTES)
           ├─────────────────────┤ ⎫   POINTERS TO NEXT LEVEL OF PLDT'S
           │     FSPT FOR        │ ⎪   I.E., SUCCESSORS TO THIS PLDT FOR
         ≈ │      NEXT         ≈ │ ⎬   EACH FUNCTION SWITCH FS(0) - FS(6)
           │      LEVEL[2]        │ ⎭   (14 BYTES)[1]
           └─────────────────────┘
```

NOTE: [1]DATA BASE SIZE FOR EACH PROCESS = 26 BYTES.

[2]FSPT FOR NEXT LEVEL REQUIRES 7 ENTRIES IN THAT "CANCEL" FUNCTION
SWITCH 7) NEED NEVER BE ALTERED FROM THE INITIAL FSPT.

FIGURE 4-5.
PROCESSING LEVEL DESCRIPTOR TABLE (PLDT) DATA BASE CONTENT
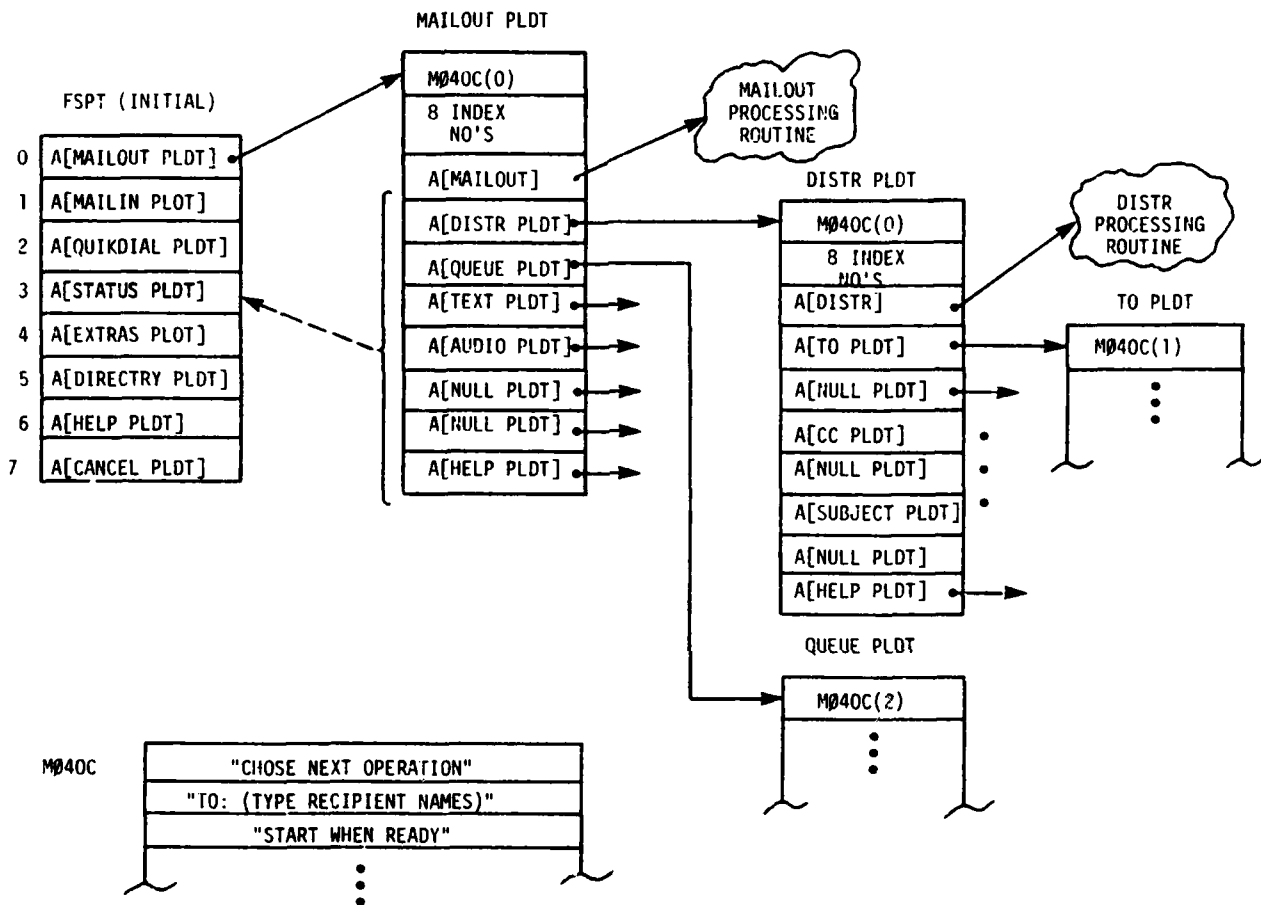
FIGURE 4-6.
REPRESENTATIVE "MAIL-OUT" FUNCTION SWITCH DATA BASE STRUCTURE

4.2.3.2 <u>Audio Switch</u>. The Audio Switch is a hardware device used by the MAILPHONE system to route the audio signals between the system devices using audio signals (coupler, handset, and ACR). This device is controlled by software sending data to two output ports. The data sent to these ports opens or closes switches connecting the audio-related devices. Section 3.2.3 provides the specific details.

4.2.3.3 <u>Audio Cassette Recorder (ACR)</u>. The ACR is used by the system to record and playback various audio messages. The ACR software is functionally partitioned into three functional modules: (1) interrupt service, (2) command processing, and (3) tape positioning.

The command processing function generates the commands to the ACR which are: (1) Play, (2) Record, (3) Fast Forward, (4) Rewind, and (5) Stop.

Once the ACR is commanded into motion, an interrupt is generated 18 times per revolution of the take-up spindle. This interrupt is processed by the ACR interrupt service function in order to maintain tape position location for tape file management. The tape positioning function is used to position the tape at the beginning of any 1-minute record gap.

4.2.3.4 <u>MODEM</u>. The MODEM is a hardware device used by the MAILPHONE system to transmit and receive text mail. The MODEM software is partitioned into transmit processing and receive processing. The receive processing is entered when an outside telephone call is made to the MAILPHONE by another MAILPHONE. The "RING DETECT" from the MODEM results in a Control Unit interrupt and the MODEM receive processing is then executed.

The MODEM transmit processing is entered from the SEND MAIL function when messages are to be transmitted to another MAILPHONE. One ASCII character is sent at a time until the entire message has been transmitted.

4.2.3.5 <u>Coupler</u>. The Coupler is a device used to connect the Control Unit to a telephone line for the sending and receiving of "live" phone calls. The Coupler software is entered as a result of the "RING DETECT" interrupt when a live call is detected by the Coupler hardware. A "ring" is generated by the Coupler software at the Desk Unit for each "Ring Detect" interrupt received.

4.2.3.6 <u>Printer</u>. The printer is used by the MAILPHONE system as a hardcopy device for viewing both incoming and outgoing text mail on a 40 character per line format. When a hardcopy is requested (function switch selection), the Printer software outputs the message exactly as composed or received, character by character, until the full message has been output.

4.2.3.7 <u>Disk</u>. The Disk is used by the MAILPHONE system for the temporary storage of files containing messages received and messages to be transmitted. The Disk is also used as a non-volatile storage media for fixed data bases such as the Directory, ACR file management information, and a complete copy of MAILPHONE Control Unit executable software used at power turn-on and for program overlays. Various file formats are used depending on the data structure to be stored or read from the disk. The software for reading and writing the Disk are called from various states of the Control Unit software depending on the user functional states. For instance, if a Directory has just been created and the SAVE option is requested, the new or updated directory is written to the Disk replacing the old directory. If a text message has just been received, the message is recorded on the Disk until the user requests the contents of MAILIN messages.

4.2.4 <u>Service Functions</u>. A number of general service functions have
been utilized in the development of the Control Unit software. These
service functions are used at many levels of software and generally
provide the software implementors a simpler interface in generating
the system software. These service functions are listed below with a
brief description of the task they perform:

    (1) Tape Position - positions the ACR tape at a given
        location.

    (2) 40-Character Display - outputs up to 40 characters
        to the Desk Unit display.

    (3) Legends - controls the Desk Unit for the generation
        of given function legend displays.

    (4) AUTODIAL/CHECK STATUS Light - controls the ON/OFF of
        both the AUTODIAL and CHECK STATUS L.E.D.'s.

    (5) Tape Availability - computes the next available location
        on tape for audio recording.

    (6) File Position - computes an index number for the next
        available file location for mail received and to be
        transmitted.

    (7) Dial - generates the electronic dialing sequence required
        for sending of mail and for normal telephone dialing.

4.2.5 <u>Data Bases</u>. A number of data bases are required by the Control
Unit software in order to implement the MAILPHONE functional states.
Not all of these data bases will be addressed here, only those that are
required for the actual transmission and reception of electronic mail
will be discussed. This also includes those data bases required to create,
edit and view text messages and for the ACR tape format. Refer to Figure
4-7 for a pictorial representation of these data bases. The acronyms given
in the box at the top of each data base structure is the software symbol
used.

(1) DIRECTORY

DIRNME	DIRNUM
(Directory Names)	(Directory Numbers)
10 Entries	10 Entries

DIRCNT

(Directory Count)

(2) MAIL-OUT HEADER BUFFER

MOBUF
Directory Phone Index
Date/Time "SEND"
TEXT TYPE
Message Length/No
Date/Time Transmitted
FROM:
TO:
CC:
SUBJECT:

(3) TEXT GENERATION
     BUFFER

ACTBUF
Text Generation and Edit Buffer (40 char. X 25 Lines)

(4) MAIL-IN HEADER
     BUFFER

MIBUF
SAME AS MOBUF

(5) TEXT TRANSMIT/
     RECEIVE BUFFER

RTBUF
Transmit and Receive TEXT Mail (40 char. X 25 Lines)

(6) ASSEMBLY BUFFER

1 LINE X 40 CHARACTER DISPLAY BUFFER

FIGURE 4-7.
SOFTWARE DATA BASE STRUCTURES

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4.2.5.1 <u>Directory</u>. The Directory contains 10 entries, each of a 20-character (ASCII) name and the associated 10-digit telephone number with an indication as to whether this is a valid MAILPHONE number. Entries are made into the Directory by the user from the Desk Unit keyboard when in the DIRECTORY-EDIT system state. These entries are used for directory phone number look-up when sending messages and autodialing.

The Directory is kept as a file on disk. The Directory is updated when new entries are made or when current entries are edited. The actual edit changes and entries are processed in the Assembly Buffer (Figure 4-7). This processing controls the edited directory information display. A single variable is used to keep count of the number of Directory entries.

4.2.5.2 <u>MAIL OUT Header Buffer</u>. The MAIL OUT Header Buffer is used for the creation of the necessary header information to transmit and receive MAILPHONE text and audio messages. The header contains the following information, not all of which is actually transmitted (indicated in Figure 4-7 by the dashed line).

Data	Description
(1) Phone Index	Index number into the Directory for a phone number.
(2) Date and Time "SEND" Pushed	The date and time that the user pushed the SEND function switch to send this message.
(3) Text Type	Indication of TEXT or AUDIO message associated with this header.
(4) Message Length	If the message is TEXT then this contains the number of characters in the text; if the message is audio, this contains the start position on tape for the message.

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(5) Date and Time Transmitted	The date and time that the message was successfully transmitted to another MAILPHONE.
(6) FROM	Contains the user's name (20 ASCII characters).
(7) TO	Contains the "TO:" entry for distribution. The characters entered by the user here are compared against the Directory entries to obtain the Phone index (item 1 above).
(8) CC	Contains the "CC:" characters for distribution as entered by the user.
(9) SUBJECT	Contains the user entries for the "SUBJECT" of this message.

The data entered from the keyboard in the generation of a message header by the user is stored directly to, and displayed from, this buffer (TO, CC, SUBJ, FROM). All of the data contained in the header is stored on a disk file for subsequent transmission.

4.2.5.3 <u>Text Generation Buffer</u>. The Text Generation buffer is used as the actual working area for the composition and editing of TEXT messages. This buffer is represented to the user as a 40-character by 25-line message area and each line of the buffer can be viewed by the user using keyboard control characters. ASCII characters, entered at the keyboard are sent to the Control Unit from the Desk Unit and entered directly into this buffer. The Text Generation Buffer is stored in its entirety on a disk file for subsequent transmission.

4.2.5.4 <u>MAIL IN Header Buffer</u>. The MAIL IN Header Buffer is used for the actual transmission of the header information created in the MAIL OUT Header Buffer. This allows for the creation of new messages while transmitting messages already created. Additionally, the MAIL IN Header Buffer is used for the reception of header information from other MAILPHONES

since both transmission and reception of messages can not occur simultaneously. All header information received is filed on disk for subsequent display when requested by the user under MAIL-IN.

4.2.5.5 <u>Text Transmission and Receiving Buffer</u>. The Text Transmission and Receiving Buffer is used for the actual transmission and receiving of TEXT messages to and from other MAILPHONES. Text data to be transmitted is read from a disk file to this buffer and then transmitted. Likewise, received TEXT messages are stored, character by character, in this buffer until the full message is received. The TEXT data received in this buffer is filed on disk for subsequent display to the user when requested.

4.2.5.6 <u>Assembly Buffer</u>. The Assembly Buffer is used for the assembly of data for display (40-character) that would not otherwise be viewable from existing buffers. The Directory information is assembled in the Assembly Buffer from the Directory data base. MAIL IN header information is assembled in the Assembly Buffer from the MAIL OUT header buffer when "MAIL IN QUEUE" information is requested. When the Directory is being edited, this buffer is also used as the working/display buffer.

4.2.5.7 <u>Audio Tape Format</u>. The ACR tape format is essentially divided into one minute recording segments used for the recording of MAILOUT and MAILIN audio messages. The "beginning of tape" is followed by one-minute pre-allocated tape segments. These segments were fixed in size to allow for ease of ACR tape management when deleting and adding messages.

4.2.6 <u>Text Generation and Editing</u>. The Text Generation and Editing software is functionally partitioned into two modules as shown in Figure 4-8. The first module is for the generation of outgoing (MAILOUT)
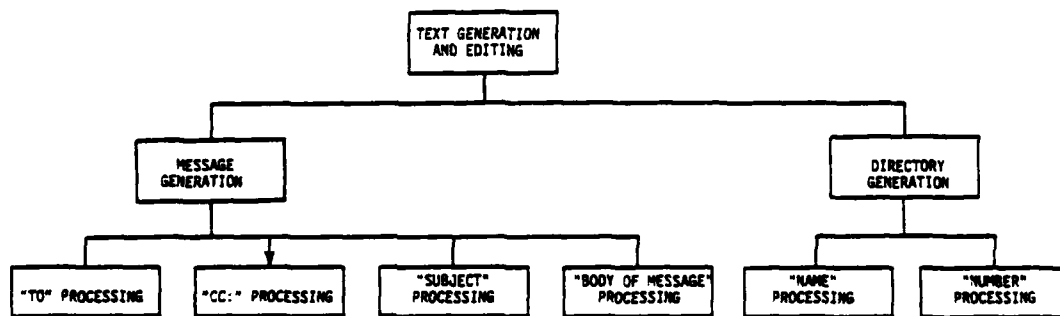
FIGURE 4-8.
TEXT GENERATION AND EDITING FUNCTIONAL DIAGRAM

messages. This functional module is further partitioned, as shown, into "TO," "CC," "SUBJECT," and "Body of Message" processing. Each of these functional modules are selected by the user by a function switch and the portion of the MAILOUT Header Buffer or Text Generation buffer selected is displayed to the user. The user can then create text and edit within the selected buffer until another selection is made. Since the TO, CC, and SUBJECT buffers are all 40 characters in length, all text generation and editing are confined to that buffer (e.g., CURSOR UP/DOWN has no meaning for a single line).

The second module is for the generation and editing of the Directory. This functional module is also partitioned into two additional modules, one for the generation and editing of Directory names and the other for the generation and editing of Directory numbers. While each module, like the TO, CC, etc. processing, is selected by the user with a function switch, both the Directory name and number (including area code) are assembled and displayed to the user on one line. The function switch selection restricts the actual character generation and editing to the area displayed for either NAME or NUMBER but NEXT LINE and BACK LINE move the displayed "WINDOW" up and down the directory entries, always displaying both on the single line display.

4.2.7   MAILPHONE To MAILPHONE Message Protocol. The MAILPHONE to MAILPHONE message protocol is a set of rules that are followed by the MAILPHONE Control Units when interconnected by telephone lines for the transmission and receiving of TEXT and AUDIO messages. The basic functions of the Control Unit software in implementing the protocol are to:

(1) Establish and terminate a telephone line connection between two MAILPHONE units.

(2) Assure message integrity through error detection, requests for retransmission and positive or negative acknowledgements.

These functions are performed by the MAILPHONE Control Unit software ("SEND/RECEIVE MAIL") as defined in Figure 4-9. The left half of the figure represents the "TRANSMITTER" MAILPHONE while the right side is the "RECEIVER" MAILPHONE. The items listed 1 through 10 indicate what function the TRANSMITTER is performing and at the same time, with the corresponding item number, what function the RECEIVER is performing.

The first level of protocol is to establish the connection between the MAILPHONES. This is accomplished by the automatic dialing by the "TRANSMITTER." When the dial is complete, a "RING DETECT" interrupt is generated by the RECEIVER MODEM and the "RECEIVER" unit goes "OFF-HOOK." This is detected by the "TRANSMITTER" MODEM from the "CARRIER DETECT" bit of the MODEM status word. At this time the "TRANSMITTER" software sends the ASCII control character "ENQ" (enquire) to establish the first level of "handshake" with the "RECEIVER." The "RECEIVER" responds by sending back to the "TRANSMITTER" the ASCII control character "ACK" (acknowledge). The "TRANSMITTER" now knows that the "RECEIVER" is "on-line" functioning properly. The "TRANSMITTER" then sends the message header information (see DATA BASE section for the Control Unit) one ASCII character at a time at a rate of 300 baud. As each character of the header is transmitted both the "TRANSMITTER" software and "RECEIVER" software compute a checksum by adding each of the characters in the header. At the completion of sending the header, the "TRANSMITTER" sends the two byte (16 bits) accumulated checksum and the "RECEIVER" then compares this value with its own computed checksum as characters were being sent. If the checksums do not compare, then the "RECEIVER" sends the ASCII control

TRANSMITTER
(SEND MAIL)

MAILPHONE
CONTROL UNIT

TELEPHONE
LINE
CONNECTION

MODEM

MODEM

RECEIVER
(RECEIVE MAIL)

MAILPHONE
CONTROL UNIT

ACR

ACR
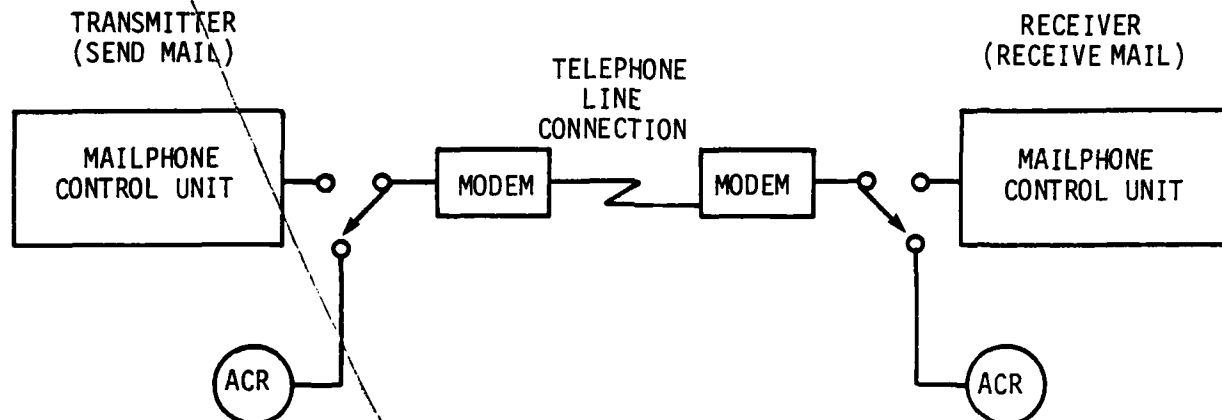
TRANSMITTER FUNCTIONAL STEPS

1. DIAL PHONE NUMBER (5 Rings Max)

2. SEND "ENQ"

3. WAIT "ACK"

4. SEND MESSAGE HEADER & CHECKSUM

5. WAIT "ACK/NAK" (ACK=6, NAK=2)

6. SEND "STX"

7. WAIT "ACK/NAK" (ACK=8, NAK=EXIT)

RECEIVER FUNCTIONAL STEPS

1. MODEM INTERRUPT (CARRIER DETECT)

2. WAIT "ENQ"

3. SEND "ACK"

4. RECEIVER HEADER (COMPUTE CHECKSUM)

5. SEND "ACK/NAK" (ACK=6, NAK=2)

6. WAIT "STX"

7. SEND "ACK/NAK"

TEXT	AUDIO	TEXT	AUDIO
8. SEND TEXT & CHECKSUM	8. SEND AUDIO	8. RECEIVE TEXT (COMPUTE CHECKSUM)	8. RECEIVE AUDIO (1 MINUTE)
9. WAIT "ACK/NAK" (ACK=10, NAK=6)	9. WAIT "ACK"	9. SEND "ACK/NAK" (ACK=10, NAK=6)	9. SEND "ACK"
10. EXIT	10. EXIT	10. EXIT	

FIGURE 4-9.
SEND/RECEIVE MAIL FUNCTIONAL PROTOCOL FLOW DIAGRAM

character "NAK" (negative acknowledge) and both the "TRANSMITTER" and "RECEIVER" return to step 2 of Figure 4-9 for another attempt at sending the "header" information. Three attempts are made at sending the header, and if all result in "NAK" from the "RECEIVER" as a result of an incorrect checksum comparison, then both "TRANSMITTER" and "RECEIVER" exit the processing. An attempt to redial is started by the "TRANSMITTER" 8 seconds later if no other outgoing messages are pending. When the checksums do compare (ACK from the "RECEIVER"), then the "TRANSMITTER" sends the ASCII control character "STX" (start of text). If the header information indicates a "TEXT" message then the "RECEIVER" immediately responds with the control character "ACK," but if the message is "AUDIO," the "RECEIVER" checks for an ACR tape location for the recording, positions the tape to that position, and then sends "ACK" to the "TRANS-MITTER." If no tape segment is available, then the "RECEIVER" sends the "NAK" and both the "RECEIVER" and "TRANSMITTER" go "off-line" and EXIT the functions. For a "TEXT" message, the "TRANSMITTER" sends the TEXT characters and computes a checksum as with the header. Again, the "RECEIVER" compares its computed checksum with that sent from the "TRANSMITTER" and responds with either the "ACK" or "NAK" ASCII control characters, depending on a valid compare. The "NAK" ASCII results in both the "TRANSMITTER" and "RECEIVER" attempting a "TEXT" message retransmission starting at step 6 in Figure 4-9. Again, three attempts are made before going "off-line." For an "AUDIO" message there is no checksum computation (audio information) and after 1 minute of recording, the "RECEIVER" always responds with "ACK" at which time both "TRANSMITTER" and "RECEIVER" go "off-line." Figure 4-10 shows a time line representation of "TEXT" and "AUDIO" message block information and protocol.

A. TEXT MESSAGE

TRANSMITTER: | ENQ[1] | | S_{O_H}1 | HEADER | E_{O_H}2 | C/S[2] | | STX | | TEXT MSG. | E_{T_X} | C/S[2] |

RECEIVER: | ACK | | ACK / NAK | | ACK | | ACK / NAK |

TIME LINE REPEATED   TIME LINE REPEATED

B. AUDIO MESSAGE

TRANSMITTER: | ENQ | | S_{O_H} | HEADER | E_{O_H} | C/S | | STX | | AUDIO (1 MINUTE) |

RECEIVER: | ACK / NAK | | ACK / NAK | | ACK |

TIME LINE REPEATED
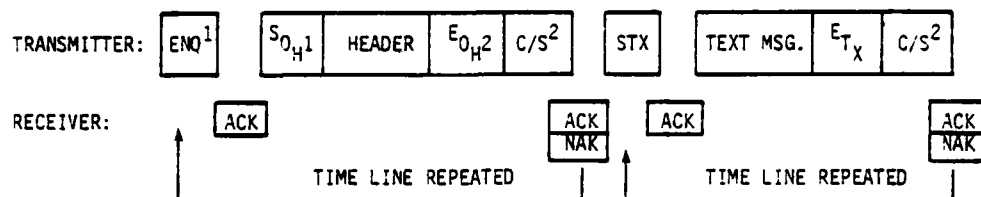
EXIT
TIME LINE
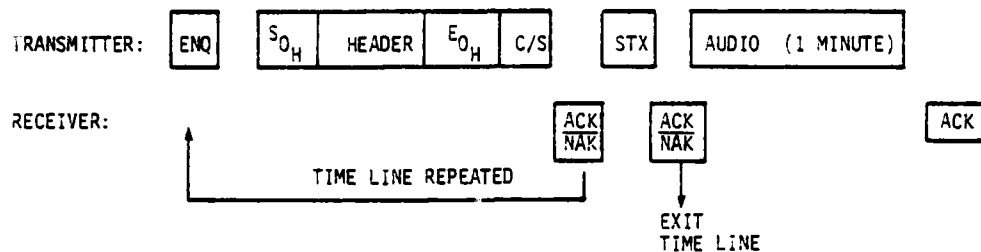
NOTES: [1]ASCII CONTROL CHARACTERS

ENQ = ENQUIRY

SOH = START OF HEADER

EOH = END OF HEADER

ACK = ACKNOWLEDGE

NAK = NEGATIVE ACKNOWLEDGE

STX = START OF TEXT

ETX = END OF TEXT

[2]C/S = CHECKSUM

FIGURE 4-10.
TEXT/AUDIO MESSAGE BLOCK FORMAT AND PROTOCOL TIME LINE

5. SUMMARY

At the time of writing this report, three desk units have been completely
fabricated. In terms of the QUIESCENT state function menu, the functions
implemented thus far are: MAILOUT - text message generation distribution
list creation and queue status; DIRECTRY - search and edit; CANCEL - imple-
mented at all levels of the variable legend menu; QUIKDIAL - speed dialing
and redialing of last attempted number. The Audio recording feature under
MAILOUT is being debugged. Two-way MAILPHONE communication and text and
audio message reception under the MAILIN function are being implemented.
As far as games are concerned, Blackjack (Twenty-1) has been coded and
will be integrated with the MAILPHONE software following total checkout of
all electronic mail handling and executive functions.

The physical appearance of the Desk Unit is both aesthetically pleasing
and familiar. The Desk Unit looks like a GTE telephone with a more ela-
borate face plate. It is worth recalling that the single line display
was primarily selected because its selection was in keeping with the
MAILPHONE's telephone-like (and not a computer terminal-like) appearance.
However, this selection potentially made other MMR problems rather
difficult to overcome. For instance, it is difficult to create clear,
concise unambiguous prompts with a single-line 40-character display
especially if the prompt was geared to making a menu selection. It is
in instances like these that the variable legend functions keys were
found to be most useful. Devoting the top six L.E.D readouts associated
with these keys to display the menu choices and the single line 40-
character display to provide clarifying prompts virtually "opened up"
the single-line display into a multi-line display! It became possible to
pose questions or make clarifying comments with some semblance of per-
sonality. It may be argued that a single line display used in Times
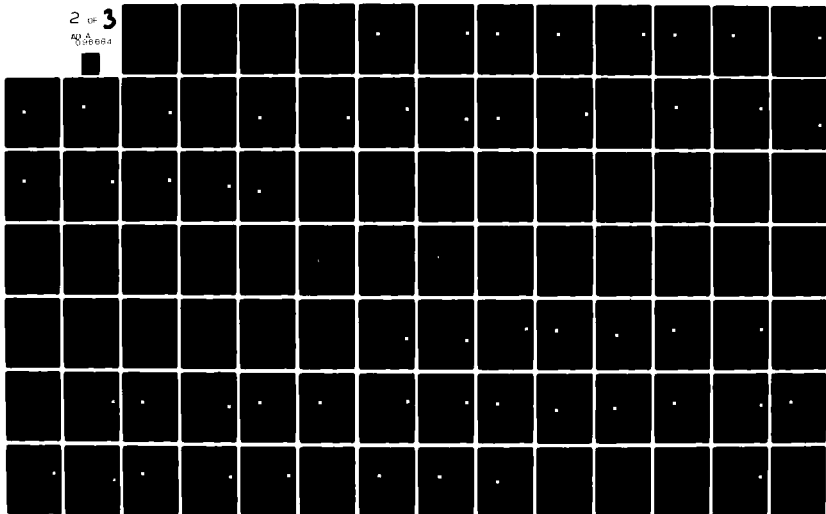
Square mode or Saccadic Scroll mode could display multiple lines. However, it is worth noting that the prompts would disappear from view in each of these instances (often sooner than the user might like them to!). This undesirable feature associated with the latter implementation can potentially burden the user and detract from the congenial MMR of the MAILPHONE system.

The display mode study provided some interesting results. These results reinforced and validated our belief that Saccadic Scroll is superior to Times Square text presentation for both reading and comprehension. It was gratifying to see that our selection of the Hewlett Packard HDSP-2001 yellow L.E.D.'s lived up to expectation. The characters are both crisp and easy to read. The "beep" that accompanies the refreshing of the display in response to user action is both reassuring and pleasant.

The single-line text generator is neither an elaborate word-processor nor a cumbersome command-oriented editor. Rather, it is a display-oriented cursor-cued text editor designed for both ease of use and compatibility with the underlying capabilities of the keyboard. The membrane keyboard layout and compact size do not in any way detract from its functionality. The 'click' feedback associated with each keypress on the keyboard has a very positive feel. The key pressure empirically determined to be around 3-4 psi is just right. It is neither too hard, nor too soft. Appropriate visual and audible feedback that occur in response to user-initiated or system-initiated action are helpful, attention-getting, and above all, friendly.

After the two-way MAILPHONE communication for both text and audio message has been implemented, a demonstration of two prototype MAILPHONE systems communicating with each other will be given at DARPA's Cybernetic Technology Division office. These systems will feature: (1) text message

composition, modification, transmission, reception (storage), review
and print; (2) audio message recording, rerecording (correction), trans-
mission, reception and playback; (3) normal phone operations; and (4)
executive phone functions, i.e., on-line directory, fast-dialing and
redial of last unsuccessfully attempted number.

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APPENDIX A

SAMPLE INTERACTION FOR MAILOUT FUNCTION

18 FEBRUARY 11:32 am

	MAIL OUT	MAIL IN	
	QUIKDIAL	STATUS	
	EXTRAS	DIRECTRY	
	HELP	CANCEL	

```
┌─────────────────────────────────────────────────────────┐
│                                                         │
│          CREATE MESSAGE OR INSPECT QUEUE                │
│                                                         │
└─────────────────────────────────────────────────────────┘
```

	DISTR	QUEUE*	■
	TEXT	AUDIO	
	HELP	CANCEL	

*QUEUE LIT ONLY IF MESSAGE QUEUE NOT EMPTY

'START' WHEN READY

START

HELP   CANCEL

1 FIELDS, ARPA ACTIVITY, 10 AUG 0137

```
[■]   [ NEXT ]   [ DELETE ]   [ ]

[ ]   [       ]   [        ]   [ ]

[ ]   [       ]   [        ]   [ ]

[ ]   [ HELP ]   [ CANCEL ]   [ ]
```

HIT 'NEXT' A FEW TIMES

16 WELTMAN, MAILPHONE REVIEW, 10 OCT 0165

	NEXT	DELETE	
	HELP	CANCEL	

16 DELETED

START

HELP   CANCEL

19 FREEDY, ROME AIR PROP, 11 OCT 0215

	NEXT	DELETE	
	HELP	CANCEL	

```
┌─────────────────────────────────────────────────────────────────┐
│                                                                   │
│              END QUEUE.   REPEAT OR MAKE NEW CHOICE               │
│                                                                   │
└─────────────────────────────────────────────────────────────────┘


        ┌──────┐    ┌──────────────┐    ┌──────────────┐    ┌──────┐
        │      │    │    DISTR      │    │    QUEUE     │    │██████│
        └──────┘    └──────────────┘    └──────────────┘    └██████┘

        ┌──────┐    ┌──────────────┐    ┌──────────────┐    ┌──────┐
        │      │    │    TEXT       │    │    AUDIO     │    │      │
        └──────┘    └──────────────┘    └──────────────┘    └──────┘

        ┌──────┐    ┌──────────────┐    ┌──────────────┐    ┌──────┐
        │      │    │              │    │              │    │      │
        └──────┘    └──────────────┘    └──────────────┘    └──────┘

        ┌──────┐    ┌──────────────┐    ┌──────────────┐    ┌──────┐
        │      │    │    HELP       │    │   CANCEL     │    │      │
        └──────┘    └──────────────┘    └──────────────┘    └──────┘
```

BACK TO FIRST MESSAGE DISPLAY

CREATE MESSAGE OR INSPECT QUEUE

	DISTR	QUEUE*	
■	TEXT	AUDIO	
	HELP	CANCEL	

```
┌─────────────────────────────────────────────────────────────────┐
│                TYPE MESSAGE THEN CREATE DISTRIBUTION              │
└─────────────────────────────────────────────────────────────────┘
```

```
┌─────┐   ┌─────────────┐   ┌─────────────┐   ┌─────┐
│█████│   │    DISTR     │   │             │   │     │
└─────┘   └─────────────┘   └─────────────┘   └─────┘

┌─────┐   ┌─────────────┐   ┌─────────────┐   ┌─────┐
│     │   │             │   │             │   │     │
└─────┘   └─────────────┘   └─────────────┘   └─────┘

┌─────┐   ┌─────────────┐   ┌─────────────┐   ┌─────┐
│     │   │             │   │             │   │     │
└─────┘   └─────────────┘   └─────────────┘   └─────┘

┌─────┐   ┌─────────────┐   ┌─────────────┐   ┌─────┐
│     │   │    HELP      │   │   CANCEL     │   │     │
└─────┘   └─────────────┘   └─────────────┘   └─────┘
```

TYPE: WOULD YOU LIKE TO MEET AT PERCEPTRONICS ON MONDAY, JUNE 22 AT 9 A.M.

USE EDIT FUNCTIONS: WOULD LIKE TO MEET YOU AT PERCEPTRONICS ON TUE, JUNE 23, AT 2 P.M

THEN HIT 'DISTR'

CREATE MESSAGE OR INSPECT QUEUE

	DISTR	QUEUE	
	TEXT	AUDIO	■
	HELP	CANCEL	

121 PRESS 'RECORD', THEN SPEAK INTO HANDSET

		RECORD	
	HELP	CANCEL	

121

■	RECORD		
	HELP	CANCEL	

127

PAUSE

STOP

HELP   CANCEL

131

		REWIND	
	PLAY		
	RECORD		
	HELP	CANCEL	

126

PAUSE

STOP

HELP   CANCEL

126

	FF	REWIND	
	PLAY		
■	RECORD		
	HELP	CANCEL	

141

PAUSE

STOP

HELP   CANCEL

141   CONTINUE WHEN READY

CONTINUE

HELP   CANCEL

HIT CONTINUE
SPEAK INTO HANDSET
HANG UP

PRESS DISTR TO CREATE MESSAGE HEADER

DISTR

HELP   CANCEL

```
┌─────────────────────────────────────────────────────────────┐
│                                                               │
│              TO:  (TYPE RECIPIENT NAMES)                      │
│                                                               │
└─────────────────────────────────────────────────────────────┘
          CC:  (TYPE DISTRIBUTION LIST)
          SUBJ:  (TYPE SUBJECT)
          SUBJ:  ARPA ACTIVITY ITEM
```

	TO	SEND*	■
	CC		
	SUBJECT		
	HELP	CANCEL	

DISPLAY 'SEND' AFTER ONE ITERATION OF TO, CC AND SUBJECT IS COMPLETE

```
┌─────────────────────────────────────────────────────────────┐
│                                                             │
│         MESSAGE SENT, CHOOSE NEXT OPERATION                 │
│                                                             │
└─────────────────────────────────────────────────────────────┘


        ┌────┐    ┌──────────┐    ┌──────────┐    ┌────┐
        │    │    │  DISTR   │    │  QUEUE*  │    │    │
        └────┘    └──────────┘    └──────────┘    └────┘

        ┌────┐    ┌──────────┐    ┌──────────┐    ┌────┐
        │    │    │  TEXT    │    │  AUDIO   │    │    │
        └────┘    └──────────┘    └──────────┘    └────┘

        ┌────┐    ┌──────────┐    ┌──────────┐    ┌────┐
        │    │    │          │    │          │    │    │
        └────┘    └──────────┘    └──────────┘    └────┘

        ┌────┐    ┌──────────┐    ┌──────────┐    ┌████┐
        │    │    │  HELP    │    │  CANCEL  │    │████│
        └────┘    └──────────┘    └──────────┘    └████┘
```

TO QUIESCENT MENU

```
┌─────────────────────────────────────────────────────────────┐
│                    CHOOSE NEXT OPERATION                      │
└─────────────────────────────────────────────────────────────┘


    ███████      ┌──────────┐      ┌──────────┐      ┌────┐
    ███████      │  DISTR   │      │  QUEUE   │      │    │
    ███████      └──────────┘      └──────────┘      └────┘

    ┌────┐       ┌──────────┐      ┌──────────┐      ┌────┐
    │    │       │   TEXT   │      │  AUDIO   │      │    │
    └────┘       └──────────┘      └──────────┘      └────┘

    ┌────┐       ┌──────────┐      ┌──────────┐      ┌────┐
    │    │       │          │      │          │      │    │
    └────┘       └──────────┘      └──────────┘      └────┘

    ┌────┐       ┌──────────┐      ┌──────────┐      ┌────┐
    │    │       │   HELP   │      │  CANCEL  │      │    │
    └────┘       └──────────┘      └──────────┘      └────┘
```

```
TO:  (TYPE RECIPIENT NAME(S))
```

```
CC:  (TYPE DISTRIBUTION LIST)
SUBJ:  (TYPE SUBJECT)
```

	TO	TEXT	■
	CC	AUDIO	
	SUBJECT		
	HELP	CANCEL	

```
┌─────────────────────────────────────────────────────────────┐
│                                                               │
│                   TYPE MESSAGE, THEN SEND                     │
│                                                               │
└─────────────────────────────────────────────────────────────┘


     ┌─────┐   ┌─────────────┐   ┌─────────────┐   ┌─────┐
     │     │   │    DISTR     │   │    SEND     │   │█████│
     └─────┘   └─────────────┘   └─────────────┘   └─────┘

     ┌─────┐   ┌─────────────┐   ┌─────────────┐   ┌─────┐
     │     │   │             │   │             │   │     │
     └─────┘   └─────────────┘   └─────────────┘   └─────┘

     ┌─────┐   ┌─────────────┐   ┌─────────────┐   ┌─────┐
     │     │   │             │   │             │   │     │
     └─────┘   └─────────────┘   └─────────────┘   └─────┘

     ┌─────┐   ┌─────────────┐   ┌─────────────┐   ┌─────┐
     │     │   │    HELP      │   │   CANCEL    │   │     │
     └─────┘   └─────────────┘   └─────────────┘   └─────┘
```

TYPE: WOULD YOU LIKE TO MEET AT PERCEPTRONICS ON MONDAY, JUNE 22 AT 9 A.M.?

USE EDIT FUNCTIONS: WOULD LIKE TO MEET YOU AT PERCEPTRONICS ON TUE, JUNE 23 AT 7 P.

THEN HIT 'SEND'

	TO	TEXT	
	CC	AUDIO	
	SUBJECT		
	HELP	CANCEL	

```
┌─────────────────────────────────────────────────────────────────┐
│ 121   PRESS "RECORD" THEN TALK                                    │
│                                                                   │
└─────────────────────────────────────────────────────────────────┘
```

```
┌────┐  ┌──────────────┐   ┌──────────────┐   ┌────┐
│    │  │              │   │              │   │    │
└────┘  └──────────────┘   └──────────────┘   └────┘

┌────┐  ┌──────────────┐   ┌──────────────┐   ┌────┐
│    │  │              │   │              │   │    │
└────┘  └──────────────┘   └──────────────┘   └────┘

┌────┐  ┌──────────────┐   ┌──────────────┐   ┌────┐
│████│  │   RECORD     │   │              │   │    │
└────┘  └──────────────┘   └──────────────┘   └────┘

┌────┐  ┌──────────────┐   ┌──────────────┐   ┌────┐
│    │  │    HELP      │   │   CANCEL     │   │    │
└────┘  └──────────────┘   └──────────────┘   └────┘
```

PRESS 'RECORD'

SPEAK INTO HANDSET

HANG UP WHEN DONE

		PAUSE	
		STOP	
	HELP	CANCEL	

HANG UP WHEN DONE

		CONTINUE	
	HELP	CANCEL	

HIT "CONTINUE"

CONTINUE RECORDING
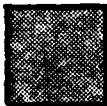
PAUSE

STOP

HELP   CANCEL

HANG UP WHEN DONE

	FF	REWIND	
	PLAY		
	RECORD		
	HELP	CANCEL	

HANG UP

MODIFY DISTRIBUTION IF NECESSARY OR SEND

	DISTR	SEND	
	HELP	CANCEL	

MESSAGE WAITING FOR TRANSMISSION

DISTR   QUEUE

AUDIO   AUDIO

HELP   CANCEL

18 FEBRUARY 11:39 A.M.

	MAIL OUT	MAIL IN	
	QUIKDIAL	STATUS	
	EXTRAS	DIRECTRY	
	HELP	CANCEL	
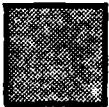
```
┌─────────────────────────────────────────────────────────────┐
│                    HANG UP WHEN DONE                         │
└─────────────────────────────────────────────────────────────┘


    ┌───┐   ┌───────────┐   ┌───────────┐   ┌───┐
    │   │   │    FF     │   │  REWIND   │   │   │
    └───┘   └───────────┘   └───────────┘   └───┘

    ┌───┐   ┌───────────┐   ┌───────────┐   ┌───┐
    │   │   │   PLAY    │   │   PAUSE   │   │   │
    └───┘   └───────────┘   └───────────┘   └───┘

    ┌───┐   ┌───────────┐   ┌───────────┐   ┌───┐
    │   │   │  RECORD   │   │   STOP    │   │   │
    └───┘   └───────────┘   └───────────┘   └───┘

    ┌───┐   ┌───────────┐   ┌───────────┐   ┌───┐
    │   │   │   HELP    │   │  CANCEL   │   │   │
    └───┘   └───────────┘   └───────────┘   └───┘


    HANG UP
```

APPENDIX B

SAMPLE INTERACTION FOR MAILIN FUNCTION

18 February, 11:32 a.m.

	MAIL OUT	MAIL IN	
	QUIKDIAL	CHECK STATUS	
	DIRECTRY	EXTRAS	
	HELP	CANCEL	

11/01   0240   FIELDS, MAILPHONE DESIGN REVIEW   T
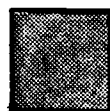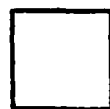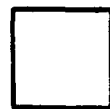
	READ		
	NEXT	PREVIOUS	
	PRINT	DELETE	
	HELP	CANCEL	

IN THE EVENT OF . . . .

STOP

PRINT

DELETE

HELP

CANCEL

IN THE EVENT OF . . . .
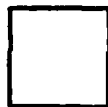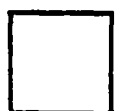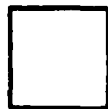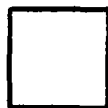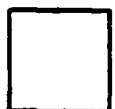
	READ		
		BACKLINE	
	PRINT	DELETE	
	HELP	CANCEL	
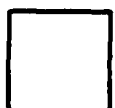
```
┌─────────────────────────────────────────────────────────────┐
│  END OF FIELD'S MESSAGE                    /                  │
│                                                               │
└─────────────────────────────────────────────────────────────┘
```

		MAIL IN	▨
	REPEAT		
	PRINT	DELETE	
	HELP	CANCEL	

11/01	0253	HAYES, CYBERCOPTER PROGRAM	A

		HEAR	
	NEXT	PREVIOUS	
		ERASE	
	HELP	CANCEL	
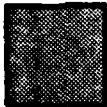
		HEAR	
	NEXT	PREVIOUS	
		ERASE	
	HELP	CANCEL	
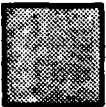
LIFT HANDSET AND PRESS 'PLAY' TO HEAR MESSAGE

PLAY

HELP   CANCEL

STOP

HELP   CANCEL

PLAY

FF

REWIND

ERASE

HELP

CANCEL

STOP

HELP   CANCEL

	PLAY		
FF	REWIND
	ERASE
HELP	CANCEL

END OF DALY'S MESSAGE

MAIL IN
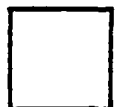
REWIND

ERASE
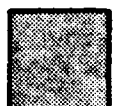
HELP   CANCEL

MSG BEING ERASED

MAIL IN

HELP

CANCEL

11/01	0310	FLETCHER, TANK GUNNER	T

	READ		
	NEXT	PREVIOUS	
	PRINT	DELETE	
	HELP	CANCEL	

MSG DELETED

NEXT   PREVIOUS

HELP   CANCEL

		HEAR	
NEXT	PREVIOUS	
		ERASE	
HELP	CANCEL	

NO MORE MSGS, PRESS 'MAIL IN' TO REVIEW

MAIL IN

PRINT

HELP   CANCEL

```
┌─────────────────────────────────────────────────────┐
│              18 FEBRUARY    11:32 a.m.                │
└─────────────────────────────────────────────────────┘


    ┌────┐   ┌──────────────┐   ┌──────────────┐   ┌────┐
    │    │   │   MAILOUT     │   │    MAILIN     │   │    │
    └────┘   └──────────────┘   └──────────────┘   └────┘

    ┌────┐   ┌──────────────┐   ┌──────────────┐   ┌────┐
    │    │   │   QUIKDIAL    │   │    STATUS     │   │    │
    └────┘   └──────────────┘   └──────────────┘   └────┘

    ┌────┐   ┌──────────────┐   ┌──────────────┐   ┌────┐
    │    │   │    EXTRAS     │   │   DIRECTRY    │   │    │
    └────┘   └──────────────┘   └──────────────┘   └────┘

    ┌────┐   ┌──────────────┐   ┌──────────────┐   ┌────┐
    │    │   │     HELP      │   │    CANCEL     │   │    │
    └────┘   └──────────────┘   └──────────────┘   └────┘
```

APPENDIX C

SAMPLE INTERACTION FOR BLACKJACK

CHOOSE YOUR DIVERSION!

	PATTERNS	TWENTY-1	
	HANGMAN	MSTRMIND	
	DATEFACT	MORE?	
	HELP	CANCEL	

CHOOSE YOUR DIVERSION!

ONELINER   ZAP

BACK?

HELP   CANCEL

CHOOSE YOUR DIVERSION!

PATTERNS   TWENTY-1

HANGMAN   MSTRMIND

DATEFACT   MORE?

HELP   CANCEL

WELCOME TO TWENTY-1

PLAY   RULES

HELP   CANCEL

WHAT DO YOU BET?

	$1	$10	
	$2	$20	
	$4	$50	
	HELP	CANCEL	

BET: $2   YOU: 7,6   DLR: ?,7

	HIT	HOLD	
	DOUBLE		
	HELP	CANCEL	

BET: $2　　　　　　YOU: 7,6,5　　　　　　DLR: ?,7

HIT

HOLD

HELP

CANCEL

BET: $2   YOU: 7,6,5   DLR: 5,7

CANCEL

SHORT PAUSE, 'BEEP,' DISPLAY REFRESHED

BET: $2	YOU: 7,6,5	DLR: 5,7,5

CANCEL

YOU WIN $2!   YOU ARE UP $2

PLAY

QUIT

HELP

CANCEL

YOU WIN $2!   YOU ARE UP $2!

| | PLAY | QUIT | |
| HELP | CANCEL | |

| BET: $2 | YOU: 8,8 | DLR: ?,A |

	HIT		HOLD	
	DOUBLE		SPLIT	███
	INSURE			
	HELP		CANCEL	

```
BET:  $2              FIRST HAND:  8,6         DLR:  ?,8
```


HIT   HOLD
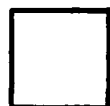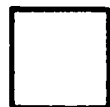
HELP   CANCEL

BET: $2   FIRST HAND: 8,6,9 (BUST!)   DLR: ?,8

PLAY

HELP   CANCEL

BET: $2   SECOND HAND: 8,J   DLR: ?,8

	HIT	HOLD	
	HELP	CANCEL	

BET: $2   SECOND HAND: 8,J (WIN!)   DLR: 6,8,3

RESULT

HELP   CANCEL

SMALL DELAY

YOU WIN SECOND HAND!   YOU ARE EVEN!   YOUR POT STILL $2

PLAY   QUIT

HELP   CANCEL

WHAT DO YOU BET?

	$1	$10	
	$2	$20	
	$4	$50	
	HELP	CANCEL	

BET: $2   YOU: 5,6   DLR: ?,7
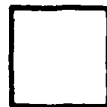
	HIT	HOLD	
	DOUBLE		
	HELP	CANCEL	

```
BET:  $4              YOU:  5,6              DLR:  ?,7
```
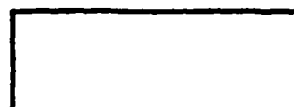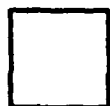
	HIT	HOLD	
	HELP	CANCEL	
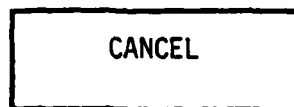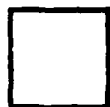
BET: $4   YOU: 5,6,8   DLR ?,7

DLR = A,7

		RESULT	
	HELP	CANCEL	

YOU WIN $4!   YOU ARE UP $6

PLAY

QUIT

HELP

CANCEL

WHAT DO YOU BET?

	$1	$10	
	$2	$20	
	$4	$50	
	HELP	CANCEL	

```
BET:  $10              YOU:  5,6              DLR:  ?,A
```

	HIT	HOLD	
		INSURE	
	HELP	CANCEL	

BET: $10   YOU: 5,6   DLR: ?,A   INS: $5

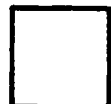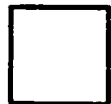|	HIT		HOLD	
	HELP		CANCEL	

```
BET:  $10              ¹YOU:  5,6,8           DLR:  J,A

                       ²YOU:  5,6,9           DLR:  8,A
                       ³YOU:  5,6,8           DLR:  9,A
```

		RESULT	▓
	HELP	CANCEL	

(1) DEALER HAS BLACKJACK

(2) PLAYER WINS $5 (POT = $11)

(3) DEALER WINS $15
     (INS + BET)

```
DRAW GAME!   YOUR POT STILL $6
```

YOU WIN $5!   YOU ARE UP $11
YOU LOSE $15!   YOU ARE DOWN $9

	PLAY	QUIT	
	HELP	CANCEL	

APPENDIX D

SAMPLE INTERACTION FOR PATTERNS

CHOOSE YOUR DIVERSION!

	PATTERNS	TWENTY-1	
	HANGMAN	MSTRMIND	
	ONELINER	MORE?	
	HELP	CANCEL	

WELCOME TO PATTERNS!

	PLAY	RULES	
	HELP	CANCEL	

CHOOSE LEVEL OF DIFFICULTY

EASY

MEDIUM

HARD

HELP   CANCEL

```
┌─────────────────────────────────────────────────────────────────┐
│                      WATCH THE PATTERN...                         │
└─────────────────────────────────────────────────────────────────┘



   ┌─────┐   ┌───────────────┐   ┌───────────────┐   ┌─────┐
   │  1  │   │               │   │               │   │  5  │
   └─────┘   └───────────────┘   └───────────────┘   └─────┘

   ┌─────┐   ┌───────────────┐   ┌───────────────┐   ┌─────┐
   │  4  │   │               │   │               │   │  2  │
   └─────┘   └───────────────┘   └───────────────┘   └─────┘

   ┌─────┐   ┌───────────────┐   ┌───────────────┐   ┌─────┐
   │  3  │   │               │   │               │   │  6  │
   └─────┘   └───────────────┘   └───────────────┘   └─────┘

   ┌─────┐   ┌───────────────┐   ┌───────────────┐   ┌─────┐
   │     │   │     HELP       │   │    CANCEL      │   │     │
   └─────┘   └───────────────┘   └───────────────┘   └─────┘
```

FLASHING SEQUENCE SHOWN BY NUMBERS IN FUNCTION KEYS

NOW YOU DO IT!

1			3
			2
	HELP	CANCEL	

USER PATTERN SEQUENCE SHOWN BY NUMBERS IN FUNCTION KEYS

OOOPS! HA! GOTCHA!

HELP

CANCEL

WOULD YOU LIKE TO PLAY AGAIN?

	EASY	QUIT	
	MEDIUM	NEWGAME	
	HARD		
	HELP	CANCEL	

APPENDIX E

DATA SHEETS FOR 100,000 DAY CLOCK,
AUDIO CASSETTE RECORDER, MODEM, POWER SUPPLY

100,000 DAY CLOCK
OPERATING MANUAL

INTRODUCTION

Mountain Hardware's 100,000 Day Clock is an accurate time piece for your computer. It will keep track of time in 100 microsecond intervals, up to 100,000 days. Advanced Complimentary Metal Oxide Semiconductor (CMOS) circuit draws less than 2 mA, which allows the clock to be run off a 9-volt battery for up to four days while the computer is shut down or if AC power fails.

The Clock uses 15 I/O ports for the time plus one I/O port to set the interrupt function. Using DIP switches, the user can assign these ports to any 16 consecutive 8080/Z-80 ports. The Clock is easily set by entering BCD digits one at a time at each time port. The moment you enter the first digit, the Clock stops. Then you enter the remaining digits. The Clock starts again on the first "read" command. A "write protect" switch prevents the Clock from being accidentally stopped or changed.

By using the interrupt feature of the Clock, activities relating to time of day may be preformed at preprogrammed intervals without interfering with the normal operations of the computer. You may program interruptions on any change in a Clock digit; that is, at intervals of 100 microseconds, 1ms, 10ms, and so on to 1 hour, 10 hours, etc. The board can be easily used with most BASICs. However, with our Introl BASIC, time is especially simple to set, compare, check, display and print.

Two software packages are included that expand the capabilities of the Clock board. One package gives calendar information such as month, day, year and day of week. The other package allows multiple interrupts, at any time interval, or absolute time.

The 100,000 Day Clock board, because of all the features included on one board, will enhance the power of your computer and add to it the dimension of time.

THEORY OF OPERATION

The S-100 Clock communicates to the central processor through a block of 16 I/O ports. The address of this block is determined by the setting of S1 switches 2 through 5. These select the high order 4 bits of the eight-bit I/O address for each of the 16 ports.

The block address of each port, 0 through 15, corresponds to the address of a location in the 16X4 RAM at U29. Locations 0 through 14 of this RAM each hold one of the 4-bit BCD digits of the current time. The contents are as follows:

Loc			
	0	0-9	Hundreds of microseconds.
	1	0-9	Milliseconds.
	2	0-9	Tens of milliseconds.
	3	0-9	Hundreds of milliseconds.
	4	0-9	Seconds.
	5	0-5	Tens of seconds.
	6	0-9	Minutes.
	7	0-5	Tens of minutes.
	8	0-9	if Loc 9=0 or Loc 9=1
		0-3	if Loc 9=2, Hours.
	9	0-2	Tens of hours.
	10	0-9	Days.
	11	0-9	Tens of days.
	12	0-9	Hundreds of days.
	13	0-9	Thousands of days.
	14	0-9	Ten-thousands of days.
	15		Used for interrupts.

Thus, an input operation to block address 4 will return the current number of seconds in the lower four bits of A. The information in U29 is updated by the clock every 100 microseconds. A full clock read requires 15 input operations. Since it is possible for a clock tick (update) to occur between two of the input operations, a flag is included with the data to resolve any ambiguity. If the most significant bit of A comes back set after a clock input, then the clock has not ticked since the previous input.

The clock is set by output operations to the addresses of the time digits in the block of ports. S1 (Switch 1) must be closed to write enable the clock. Outputs to block addresses 0-14 cause the lower 4 bits of the AC to be written to the corresponding digit address in U29 and STOP THE CLOCK. The clock remains stopped until the processor reads any of the time digits. The clock will then tick 100 microseconds later and continue to update every 100 microseconds.

THEORY OF OPERATION

The S-100 Clock communicates to the central processor through a block of 16 I/O ports. The address of this block is determined by the setting of S1 switches 2 through 5. These select the high order 4 bits of the eight-bit I/O address for each of the 16 ports.

The block address of each port, 0 through 15, corresponds to the address of a location in the 16X4 RAM at U29. Locations 0 through 14 of this RAM each hold one of the 4-bit BCD digits of the current time. The contents are as follows:

Loc			
	0	0-9	Hundreds of microseconds.
	1	0-9	Milliseconds.
	2	0-9	Tens of milliseconds.
	3	0-9	Hundreds of milliseconds.
	4	0-9	Seconds.
	5	0-5	Tens of seconds.
	6	0-9	Minutes.
	7	0-5	Tens of minutes.
	8	0-9	if Loc 9=0 or Loc 9=1
		0-3	if Loc 9=2, Hours.
	9	0-2	Tens of hours.
	10	0-9	Days.
	11	0-9	Tens of days.
	12	0-9	Hundreds of days.
	13	0-9	Thousands of days.
	14	0-9	Ten-thousands of days.
	15		Used for interrupts.

Thus, an input operation to block address 4 will return the current number of seconds in the lower four bits of A. The information in U29 is updated by the clock every 100 microseconds. A full clock read requires 15 input operations. Since it is possible for a clock tick (update) to occur between two of the input operations, a flag is included with the data to resolve any ambiguity. If the most significant bit of A comes back set after a clock input, then the clock has not ticked since the previous input.

The clock is set by output operations to the addresses of the time digits in the block of ports. S1 (Switch 1) must be closed to write enable the clock. Outputs to block addresses 0-14 cause the lower 4 bits of the AC to be written to the corresponding digit address in U29 and STOP THE CLOCK. The clock remains stopped until the processor reads any of the time digits. The clock will then tick 100 microseconds later and continue to update every 100 microseconds.
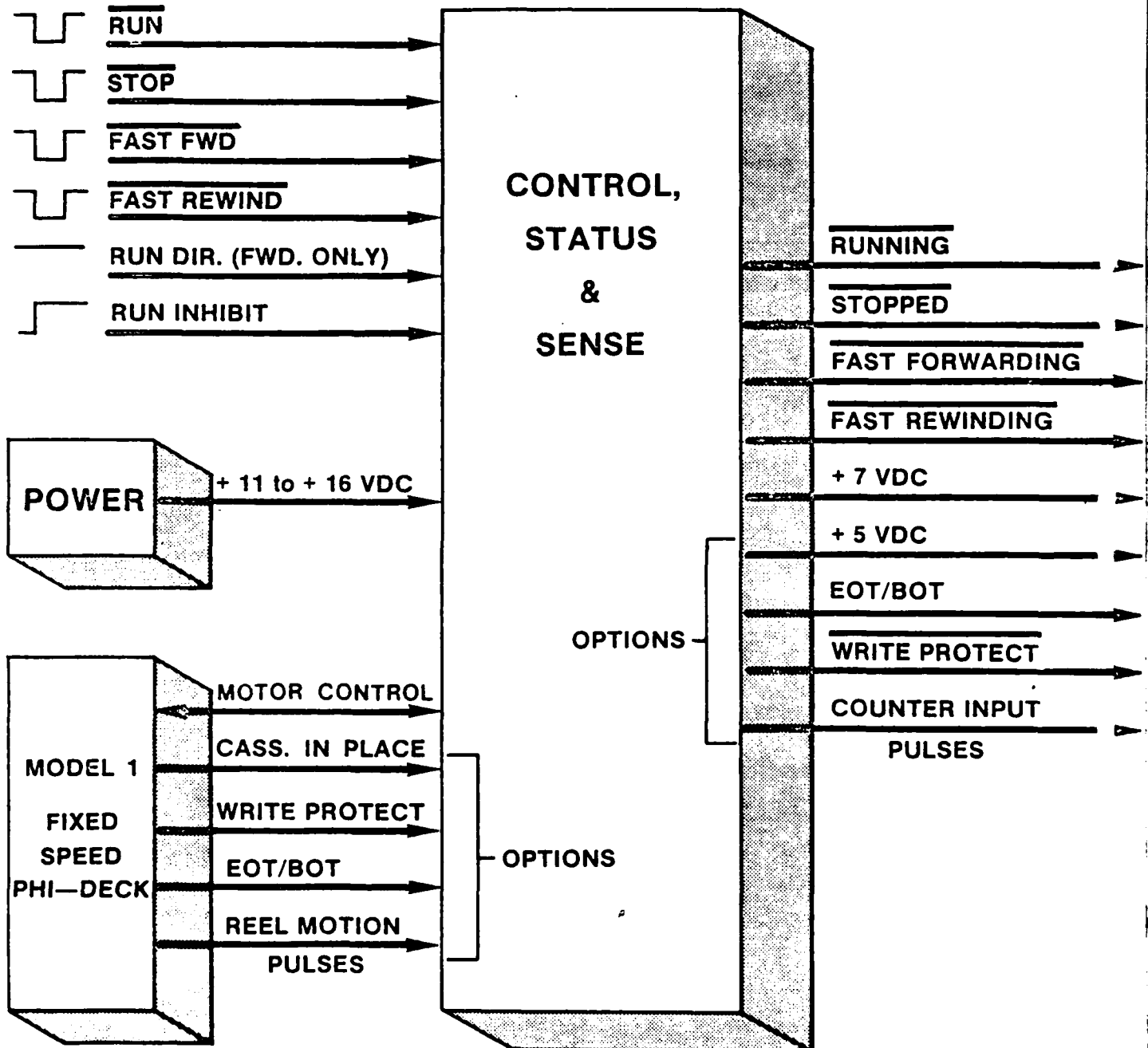
FIXED SPEED PHI-DECK MODEL #1

SPECIFICATIONS

POWER REQUIREMENT: +12V ±.2V at 1.5 amps
                                -12V ±.2V at 100 mA

RECORDING DENSITY: Up to 1600 FRPI (Flux Reversals Per Inch)

DATA CAPACITY (at 1600 FRPI):   5.76 M flux reversals per track per 300 ft.
                                cassette

ENCODING METHODS (user provided):   Most any saturated recording technique
                                    (RB, CRB, NRZ, NRZ1, PM, etc.)

DATA INTERFACE LOGIC: TTL

CASSETTE TYPE: Certified data cassette

CONTROLS: Threshold, Gain

FUNCTIONS: Play/record, stop, fast forward, and rewind

PLAY SPEEDS: 5 ips dc, 10 ips ac

WOW AND FLUTTER: Less than .25% wrms

FAST FORWARD OR
REWIND TIME: Less than 35 seconds for C-60 cassette

DRIVE SYSTEM: Capstan drive with dc motor, belt, and flywheel
                                (ac motor optional)

REEL SYSTEM: DC shielded motor for each reel

HEAD AND PINCH ROLLER
ENGAGE/DISENGAGE SYSTEM: DC motor

OPERATING POSITION: Any position, horizontal to vertical

HEADBAR ENGAGE TIME: Less than 120 ms

HEADBAR DISENGAGE TIME: Less than 120 ms

DIMENSIONS: See page 17

* Specification subject to change without notice.

1

FIXED SPEED DECK &
MOTION CONTROL BOARD
FUNCTION AND INTERFACE DIAGRAM

RUN

STOP

FAST FWD

FAST REWIND

RUN DIR. (FWD. ONLY)

RUN INHIBIT

**CONTROL,
STATUS
&
SENSE**

RUNNING

STOPPED

FAST FORWARDING

FAST REWINDING

+ 7 VDC

+ 5 VDC

EOT/BOT

WRITE PROTECT

COUNTER INPUT
PULSES

OPTIONS

POWER   + 11 to + 16 VDC

MODEL 1

**FIXED
SPEED
PHI—DECK**

MOTOR CONTROL

CASS. IN PLACE

WRITE PROTECT

EOT/BOT

REEL MOTION
PULSES

OPTIONS

With the exception of the speed control line, all non-optional input and
output lines are DTL-TTL and CMOS compatible. Optional lines are either
DTL-TTL and CMOS compatible logic signals or analog signals.

Micromodem 100™ Functional Block Diagram
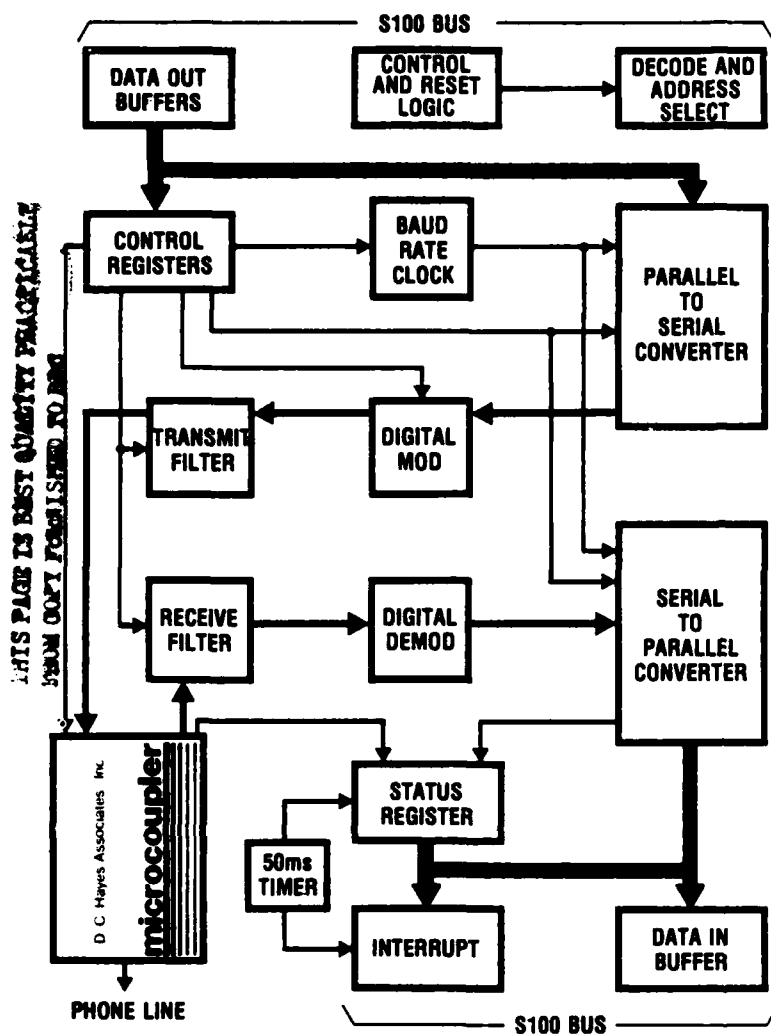
Programming the Micromodem 100™

Registers and Addressing:

The operation of the MICROMODEM 100 is controlled by software. It occupies 4 consecutive I/O port addresses on the S-100 bus. The first port is the data register. All data sent to or received from the phone line goes through this register. Modes of operation are established by setting or resetting bits in 3 control registers. Register #1 controls: parity, word length, number of stop bits and enables interrupts from the 50ms timer. Register #2 controls: baud rate, on/off hook, dialing, transmit carrier, mode, send break, self-test and transmit or receive interrupt enable. Register #3 starts the 50ms timer. The MICROMODEM 100 also has a status register which can be read by software. Status bits available are: carrier present, phone ringing, 50ms time-up, character received, transmit buffer empty, parity error, framing error and overrun error.

Automatic Reset and Disconnect:

The MICROMODEM 100 has circuits which, if enabled, can generate an interrupt or reset the CPU if the received carrier is lost. This is useful in systems which are unattended and must cold start if the connection is lost.

Interrupts:

5 interrupts are provided: character received, transmit buffer empty, phone ringing, 50ms time-up and lost carrier. All except lost carrier are individually maskable under program control.

Applications

- Convenient data communications between home and office.
- Automatic data collection from remote terminals.
- Send programs, letters, and other data over the telephone.
- Intelligent terminal.
- Access to remote data base.
- Remote software maintenance and customer support.

Ordering Information:
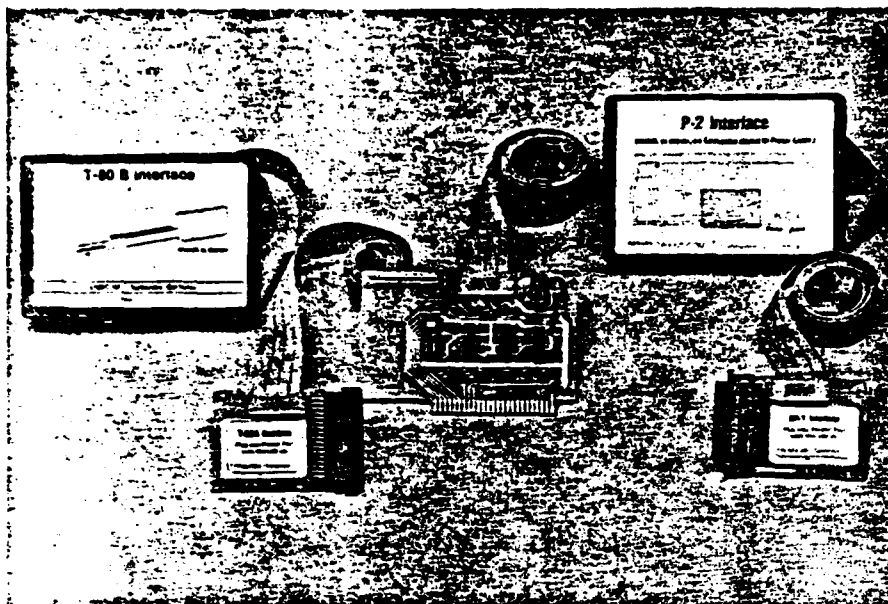
The MICROMODEM 100™ is supplied with:
- Modem interface card
- Microcoupler™
- Connector cables
- Manual including 8080 assembler listing of dumb terminal program

Ask your local computer retail outlet for price and availability information.

D.C. Hayes Associates, Inc.
MICROCOMPUTER PRODUCTS
10 Perimeter Park Drive, Atlanta, Georgia 30341 (404) 455-7663

Left to right: Trendcom interfaces for TRS-80 (with and without Expansion Interface). Apple II, PET, and Sorcerer.*

INTERFACING

Interfacing the Trendcom 200 is easy. The TTL-compatible input will work with the eight-bit parallel ports of many microcomputers. For the non-technical computerist. Trendcom offers "plug in and go" interface modules for the most popular microcomputers

TRS-80: The T-80A is an interface cable for the TRS-80 user with Expansion Interface. The T-80B plugs directly into the TRS-80 and both modules recognize the Level II LLIST and LPRINT commands.

Apple II: The A-II interface plugs into any slot in the Apple and incorporates print driver routines in ROM for the usual PR#n commands. An optional version. A-IIG. will incorporate additional firmware to allow printing Apple's Hi-Res data simply by Basic language CALL's.

PET: The P-2 interface connects to the PET's IEEE 488 connector as

Device 4 and is compatible with PET's CMD and OPEN commands. A through connector is provided to allow connecting other IEEE peripherals.

Sorcerer: The SR-1 interface cable allows direct connection to the Sorcerer's parallel printer port.

For serial communications. an RS-232 interface will be introduced in late 1979 to provide EIA level conversion and serial-to-parallel conversion.

ORDERING INFORMATION

The Trendcom 200. Interfaces. and Paper are available from Trendcom dealers throughout the U.S. and most European countries. Contact Trendcom for the address of a nearby dealer.

Trendcom 200 Specifications

TEXT

Format 80 characters per eight inch line
6 lines per inch nominal

Print speed 40 characters per second

Line Feed 50 milliseconds nominal

Character Set 96 characters. including upper and lower case, numerals. and symbols.

GRAPHICS

Format 480 seven-dot print positions per line

Print Speed 240 print positions per second

Control Codes Hex 9E clears buffer. causes line feed and carriage return. and starts graphics mode.
Hex 9F clears buffer. causes carriage return. and starts text mode.

COMMON

Interface Parallel TTL-compatible via 20-pin "ribbon cable" type connector. Eight data lines. Strobe input and Busy output. Printer does not accept data while last line is printing.

Paper 8½ inch wide thermal paper, available from Trendcom dealers in 85 foot rolls. black image on white

Power 115 VAC. 60 Hz. 20 watts (230 VAC and 50 Hz available)

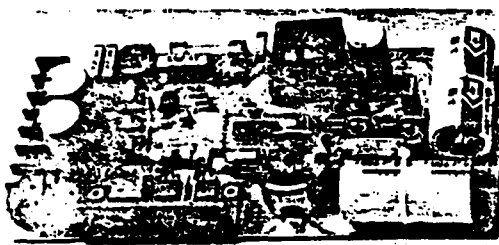**Dimensions** 12½"W x 10"D x 2¾"H (31.7cm x 25.4cm x 7cm)

Weight 8 lbs (3.6 kg).

Specifications subject to change without notice

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available from:

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FROM COPY FURNISHED TO DDC

P.C. BOARD

OPEN FRAME
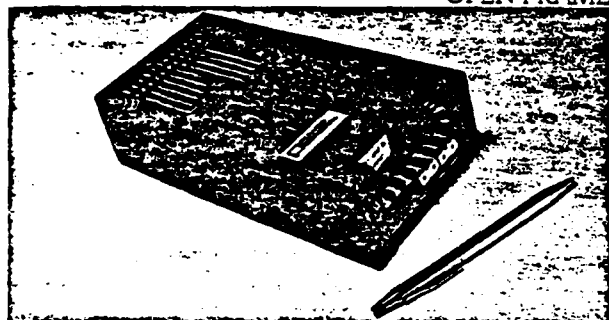
ENCLOSED UNIT

GENERAL DESCRIPTION

The 1060 Series Switching Power Supplies offers a major breakthrough in switcher design. Utilizing a proprietary conversion technique, these supplies feature high efficiency, small size, low cost, and can be purchased either as an open frame, single PC board or enclosed unit.

The supplies produce an output of 60 watts in a variety of output voltages and currents with efficiencies in excess of 75%.

By using computer grade state-of-the-art integrated circuits and discrete components, the parts count has considerably decreased as compared to older designs, thus enhancing reliability and performance. All components are carefully selected and derated to at least a minimum of 50% of their maximum ratings, for a long, reliable and trouble-free performance.

Price has also been kept low, and Power General's dollars per watt figure is one of the lowest in the industry.

PRICING (SINGLE UNIT)		
MODEL 1060-xAx	P.C. BOARD	S105
MODEL 1060-xBx	OPEN FRAME	S109
MODEL 1060-xCx	ENCLOSED UNIT	S117

TEL: (617) 828-6216
TWX: 710-348-0200

ORDERING INFORMATION

Example: 1060-1C2 depicts a power supply with output 5 VDC @ 12A, enclosed unit, factory wired for 230 VAC.

SERIES
OUTPUT VOLTAGE & CURRENT
PACKAGE OPTION
INPUT VOLTAGE FACTORY WIRING

1060 — X X X

1	5 VDC @ 12A
2	12 VDC @ 5A
3	15 VDC @ 4A

A	P.C. BOARD
B	OPEN FRAME
C	ENCLOSED UNIT

1	115 VAC
2	230 VAC

POWER
GENERAL
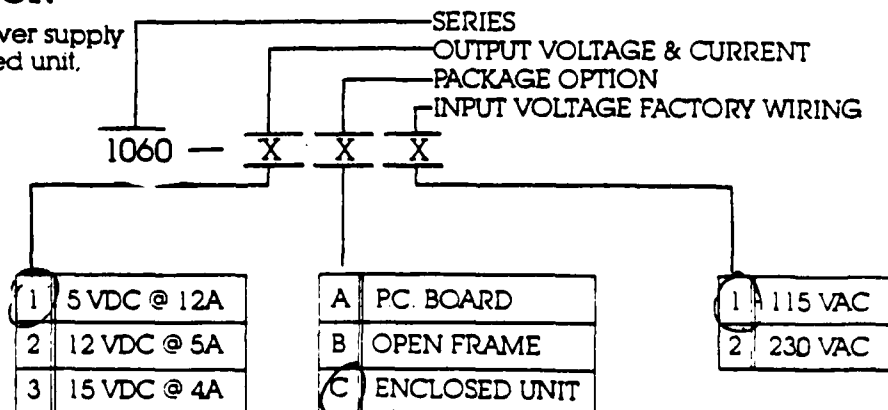
GENERAL SPECIFICATIONS
Electrical

- Efficiency — 75% Nominal
- Input Voltage Range — 90-130 } Jumper Selectable 180-260 } See page 27 for conversion information
- Input Voltage frequency Range — 45 to 450 HZ
- Frequency of operation — 20 KHZ nominal
- Output Voltages and Currents — See ordering information.
- Line Regulation — 0.1% over entire input range, all models
- Load Regulation — 0.4% from no load to full load, all models.
- Low Frequency Hum — 30 mV peak-to-peak typical. 120 HZ
- High Frequency Ripple — 50 mV peak-to-peak 5 volt model 100 mV peak-to-peak for other models as measured at 30 MHZ BW.
- Ripple, Noise & Hum — 10 mV RMS, typical
- Response time — 200 μsec to 1% for ±25% load change, with a max deviation of ±3%
- Output Voltage Overshoot — None at turn-on, turn-off or power failure
- Holdup time — Output will hold-up for a minimum of 32 msec after loss of AC power, at nominal line and load for all models.
- Inhibit — Standard on all models. Power supply will turn-off with TTL logic "1" and turn-on with TTL logic "0" applied to "INH" terminal provided on the P.C. board.
- Overvoltage protection — Shut-down type OVP, standard on all models set at 130% of nominal output voltage, ±5%. Other settings available upon request.
- Current limit — Foldback current limiting with automatic recovery, protects both power supply and load.
- Output polarity — Output is floating and may be referenced positive or negative, up to 500V off chassis ground.
- Isolation — 1000 VAC
- Soft start — Standard on all models, prevents output overshoots and power transformer saturation on turn-on.
- In-Rush Current Limiting — Standard on all models keeps turn on current below 20A

- Remote Sensing — Standard on all models, compensates for cable voltage drops up to 5% of nominal output voltage. Outputs are also internally sensed, in case sense leads are accidentally opened.
- Fusing — On-board, standard all models.
- RFI Filtering — Advanced high quality input line filter provides differential and single ended filtering of high frequency components down to acceptable levels. A three conductor input power cord is recommended.

Environmental

- Temperature Coefficient — ±0.02%/°C
- Operating Temperature Range — Full output from 0°C to 50°C with natural convection. Derate output linearity 60% at 70°C. (Note: External heatsink mounting is required for P.C. board units only)
- Storage Temperature — -55°C to +85°C

Mechanical

- Input/Output Connections — AC input, sense terminals and DC output are provided through high quality, non-breakable barrier strip. See mechanical drawings for terminal designations.
- Open Frame Units — ⅛ in. thick custom made aluminum extrusion angle, black anodized for better heat conduction, provides two surface mounting through threaded #8 stainless steel captive hardware.
- Enclosed Units — Perforated 0.04 in. thick aluminum black anodized cover, offers protection plus radiated EMI/RFI filtering.
- Printed Circuit Boards — Type FR4, glass epoxy fire retardant, on all units.
- Mechanical Specifications — See page 27
- Weight (Nominal)

Series 1060 { PC Board 1.1 lbs (0.50 kgs) Open frame 1.6 lbs (0.72 kgs) Enclosed Unit 2.2 lbs (1.0 kg)

MECHANICAL DIMENSIONS
MODEL 1060-xAx

1.90 MAX (48.26)

6-32

3/8 TYP

AC
ACG
GND
-S
-V
+V
+S

.25 (6.35)

.25 (6.35)

.140 (3.56) MTG. HOLES

AC CHASSIS GROUND

8.01 MAX (203.45)

7.50 (190.50)

.25 (6.35)

R1 V ADJ

INHIBIT

C20 REF

C16 REF

1
2
3
4

T1 REF

3.28 (83.31)

3.90 (99.06) MAX

J1

NOTE:
1. DIMENSIONS SHOWN IN INCHES, ( ) MM.
2. TB1 MARKED AS SHOWN.

.062 (1.57)

.50 (12.70)

1.80 (45.72)

1.50 (38.10)

8-32 INSERT STAINLESS STEEL

OPERATING VOLTAGES

T1 & J1 SHOWN CONNECTED FOR 115V OPERATION.

FOR 115V OPERATION	JUMP	OPEN
TERMINAL	1 TO 3 2 TO 4 J1	2 & 3
FOR 230V OPERATION	JUMP	OPEN
TERMINAL	2 TO 3	1 & 3 2 & 4 J1

P.C. BOARD

MODEL 1060-xBx
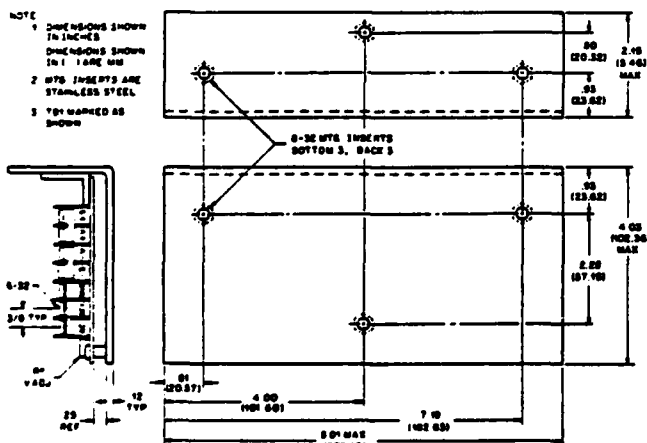
OPEN FRAME

MODEL 1060-xCx

NOTE INCH / MM

8.12 MAX / 206.25

4.25 MAX / 107.95

V ADJ

2.22 MAX / 55.88
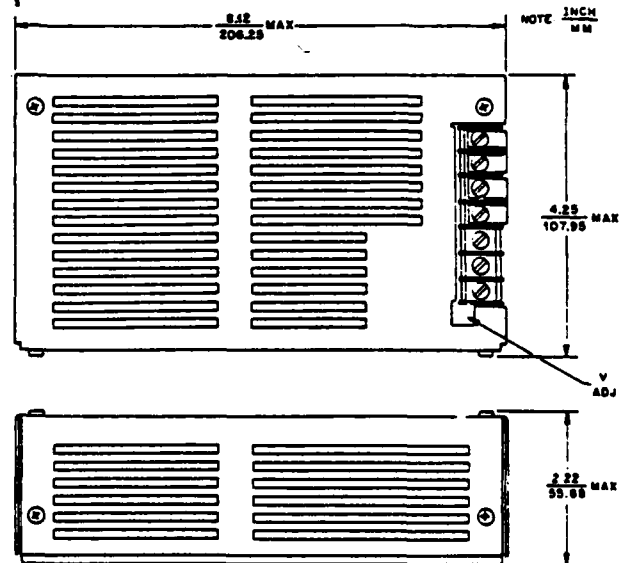
ENCLOSED UNIT

APPENDIX F

MAILPHONE DESK UNIT/CONTROL UNIT INTERFACE DESIGN AND PROTOCOL

The main user interface to the MAILPHONE is via the desk unit. Infor-
mation must pass from the desk unit informing the control unit of various
requests made by the user and likewise, the control unit must pass infor-
mation to the desk unit, to indicate to the user, various states of the
system in the form of displays and sounds. The objective of the design
given below is to minimize the amount of data on the interface, allowing
for maximum processing time in both the desk unit and control unit with
minimum error from the interface.

The data/information from the desk unit required by the control unit is
in the form of a:

      (a) Keyboard entry (ASCII character).
      (b) Function switch indication.
      (c) Handset switch indication.
      (d) Numeric pad entry.
      (e) Desk Unit error indications.

Since there are different types of information being passed from the
desk unit, a way of distinguishing these types is indicated to the control
unit via the most significant bit (MSB) of the word being sent. Defined
below is the format for the data/information from the Desk Unit to the
Control Unit.

<u>Desk Unit to Control Unit Interface Data Formats</u>

MSB
<u>76543210</u>

Control bit = 0 → bits 0-6 define the keyboard ASCII character
              1 → bits 0-6 encoded as follows:

0-7 defines which function switch pushed
8 defines keypad switch release
9-6H define desk unit error codes
21-22H define handset ON/OFF hook, respectively
30H-39H define the keypad numerical entries 0-9
2AH defines the keypad entry "*"
39H-7F unused

The data/information from the control unit to the desk unit is in the form of:

(a) 40 character display information.

(b) 64 character display information (function legends).

(c) Control information for:

. cursor position for 40/64 character displays.

. STATUS/AUTODIAL lights.

. sound generation.

Again, due to the different types of information being sent from the control unit to the desk unit, control characters are required to indicate to the desk unit which of the above given types of information is being sent. The available control characters must fall outside the range of displayable ASCII codes. Thus, control information and data from the control unit to the desk unit is as given below.

Control Unit to Desk Unit Interface Data Formats

1. Display Mode Word
76543210

0000001

└─►0 = 40 character display
    1 = 64 character display

This control character sets the ASCII character/cursor mode where all
subsequent ASCII character (>20H) or cursor control words (see below)
pertain to the display set by this word. All ASCII characters sent to
the desk unit are then displayed at the cursor position for that display.
The cursor position will be moved one character position to the right for
each ASCII character received. Additionally the cursor will "home" when
the 40/64 character display is exceeded with no additional control input.

The ASCII character sent must fall in the range of 20H-7FH. If the MSB
of the ASCII character sent = 1, then inverse video for that character
will be performed by the desk unit.

```
76543210
┌─┬──────────┐
│ │ASCII Char│
└─┴──────────┘
 ▲
 └────────1 = inverse video for ASCII character
```

2. Auto Light Control Word
```
76543210
┌──────────┬─┬─┐
│000001    │ │ │
└──────────┴─┴─┘
        │ │
        │ └──► STATUS      ⎫ 1 = on
        └────► AUTODIAL    ⎬
                           ⎭ 0 = off
```

This control word is used to turn the STATUS and AUTODIAL light ON
and OFF as indicated.

3. Function Display Control Word
```
76543210
┌─────┬───┐
│0000 │1  │
└─────┴───┘
      └──►0-7 defines which function display
```

This control word is always followed by a second word, the first (as shown) defines which of the 8 function legends is to be written to, and the second word defines an index into a set of precanned legends to be displayed at the function legend location defined by the control word.

4. Cursor Control Word

76543210

| 0001 | |

This control word is used for cursor control for the current display mode (40/64 character). Bits 0-3 are encoded for the following functions:

    0000 - no cursor display (position maintained)
    0001 - display cursor*
    0010 - home cursor
    0011 - move cursor one position left
    0100 - move cursor one position right
    0101 - rubout at current cursor position where all characters
           to the right of the cursor are repositioned one character
           to the left, e.g., display before rubout - ABCDE, display
           after rubout - ABDE
    0110 - insert at cursor position where all characters to the right
           of the cursor and at the cursor position move one character
           to the right, e.g., before insert command - ABCDE, insert
           command followed by ASCII character "F" - ABFCDE

           This command will stay in effect at the current display
           until reset by another cursor command.

    0111 - clear display and home cursor

_____

*The cursor is displayed by alternating (at a 2 hertz rate) the 5X7 dot matrix character position between the character represented at that position and all dots (35) lighted.

1000 - turn off bell and beep sounds

1001 - turn on bell sound

1010 - turn on beep sound

1011 - keyboard "click" on (once "on" the desk unit will auto-
matically generate "click" sound)

1100 - keyboard "click" off

1101 - 1111 unused

5. Special Character Control Word

76543210

`00000001`

This control word will always be followed by one additional word which
defines an index into a set of special characters for display (e.g., "◇",
"♡", etc.) to be inserted at the cursor position.

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A096 684	3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED
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	6. PERFORMING ORG. REPORT NUMBER PTR-1094-81-2

7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)
Azad Madni, Philip Gallagher, Gershon Weltman	N00014-80-C-0755

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
PERCEPTRONICS, INC. 6271 Variel Avenue Woodland Hills, CA 91367	

11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE
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	13. NUMBER OF PAGES

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16. DISTRIBUTION STATEMENT (of this Report)

UNCLASSIFIED: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

SEE BOX SIXTEEN

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Variable Legend Function Keys	Single Line Display	Electronic Mail
Computer System Networking	Computer Communication	Audio Recording
Man-Machine Relations	Communication Systems	Horizontal Scroll
Computer-Based Systems	Executive Telephone	Saccadic Scroll
User Interface Design	Membrane Keyboards	Online Directory

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This technical report covering a six-month period (July-Dec '80) describes the design of the MAILPHONE, a Man-Machine Relations (MMR) concept demonstration project in computer-based systems. The intent of this project is to show that new approaches to man-computer interface design can overcome serious problems associated with the underutilization of military computer systems. In the present project, the approach was to select a useful military computer system which was poorly designed from MMR viewpoint, redesign it with careful emphasis in the key MMR areas, and document the improvements

DD FORM 1473 EDITION OF 1 NOV 65 IS OBSOLETE
1 JAN 73

19. Key Words (continued)

Computer Games
LED Displays

20. Abstract (continued)

in acceptance and performance.

The military computer system selected for improvement was the ARPANET
electronic mail system. The MMR improvements were realized by a
complete redesign of the electronic mail interface, and demonstrated
by the MAILPHONE, a microprocessor-based system featuring a desk top
unit purposely designed to resemble the familiar telephone. The
MAILPHONE, while complex technologically, is designed to be opera-
tionally both simple and friendly.

The report provides a detailed description of MAILPHONE system concept,
including the user interface, the MMR features, and hardware imple-
mentation. The software design at the functional level is also
included.

END

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